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TROPICAL PLANT DISEASES.

Their Importance and Control.*

THAT the development, both of plantation industries and of indigenous agriculture in the tropics and sub-tropics, is being continuously hampered by epidemics of plant diseases is only too well known. So serious have some of these outbreaks been that not only have they affected a single industry but also jeopardised the whole future of certain agricultural regions. Outstanding examples may be drawn from India where epidemic diseases have broken out on palmyra, coconuts and rice; from the Sudan, where at one time black-arm threatened to destroy the whole of the cotton industry in the Gezira province; and from Jamaica and Central America, where it has not yet been possible to check the steady progress of Panama disease. Indeed, it would probably be true to say that there is no part of the tropics but harbours some plant disease which, given suitable conditions, might break out with serious results. Fortunately, the labours of plant pathologists, initiated during comparatively recent times, have afforded a certain measure of protection. More and more this work is becoming recognised as of increasing importance to the welfare of agriculture, both in temperate and tropical zones.

The study of plant pathology in the tropics is of comparatively recent origin and the earlier plant pathologists had to contend with the fact that extremely little was known of the diseases of tropical crops. Moreover, they were firstly concerned with the diseases of the great export crops and, as a result, paid little attention, with perhaps the exception of India, to those crops grown by peasant cultivators for their own use. The past decade, however, has seen a considerable improvement in this respect. Most British Colonies and especially those in Africa now have pathologists attached to their Departments of Agriculture; their major activities therefore are connected with the crops grown by small cultivators. Again, in the more advanced plantation Colonies a further stage has been reached, in that the larger plantation industries have organised their own research departments and left the Government Departments of Agriculture to concentrate on the improvement of the local crops and methods of farming.

* From a semi-popular lecture delivered by Dr. E. J. Butler, C.M.G., C.I.E., F.R.S., before Section K (Botany) of the British Association at York on 2nd September, 1932.—(*Nature*, Vol. CXXX, No. 3295.)

According to Dr. Butler "such improvements are likely to increase the responsibilities of the plant pathologists. New and improved varieties of crop plants are liable to become attacked by diseases from which the old ones had become immune through age-long selection, and more intensive methods of farming often have a similar result. The great activity in crop improvement that has been characteristic of agricultural development in the United States and Canada since the beginning of the present century, has been accompanied by such an increased call on the services of plant pathologists that each of the staple crops has, not one, but many men engaged in the study of the cause and control of the diseases to which it is liable. As similar efforts are made to improve the staple food crops of the tropics similar needs will be felt. There are clear indications from the work on rice in Japan that even in a crop such as this, which in India is one of the healthiest of all the field crops, there is a number of diseases capable of becoming formidable obstacles to the introduction of improved varieties."

"The two tropical cereals next in importance as food crops, sorghum and the bulrush millet, are much more subject to disease than rice, but very little work has been done on them in the tropics and even the full life-history of several of the common bulrush millet parasites is unknown. Still less is known of the diseases of the tropical pulses and other plants of economic importance, except those that are grown for export. Tropical plant pathology has not much to boast of in the study and control of village and field crop diseases; the number of man-years of work put into this branch of agricultural science is too small to have yielded much result and the difficulty of getting the native cultivator to change his ways, as well as his lack of means and general backwardness, has helped to induce a pessimistic outlook amongst those who are charged with the control of agricultural research and amongst the research workers themselves. Nevertheless, not only because there is great preventable loss of crops from disease in the tropics but also because a solid knowledge of the pathology of each crop plant is a necessary concomitant of all attempts at crop improvement, means must be found to surmount these difficulties. Little by little, openings for successful attack on them will appear, and however slow progress may be at first, the next 50 years are bound to see a great improvement in the crops and in the general agriculture of even the most primitive of the African Colonies. In this advance plant pathologists will have to bear an ever increasing share."

With regard to destructive epidemics of disease amongst indigenous crops in the tropics, Dr. Butler thinks that their relative infrequence "as compared with the great plantation crops is not due, as is sometimes assumed, to the circumstance that the latter generally occupy larger continuous areas under the one crop, so that disease germs can multiply and infect more readily. In India there are large areas of village lands mainly under a single crop, as rice in 70 per cent. of the cultivated land in parts of Bengal or cotton in 60 per cent. of Khandesh. Freedom from disease in these cases is probably mainly due to disease resistance having become, through long experience, the determining factor in the selection of the varieties grown, the quality of which is liable to be a secondary consideration and is often decidedly low. In the plantation industries, on the other hand, quality which will enable the produce to compete in the markets of the world is so important that hardiness may be sacrificed. Examples of destructive epidemics in these crops are numerous and are not, as in the other category, usually due to newly introduced parasites. They are just as often due to an old parasite finding in a new variety a congenial host. They are sometimes also due to the considerable financial return leading to expansion of a plantation system into areas not naturally affording optimum conditions for the growth of the plant, so that its environment may become more favourable to the parasite than the host."

In the examples which Dr. Butler selected to illustrate "the importance and control of the diseases of tropical plants, there is every gradation in severity from the sorghum smut which levies a moderate toll of about ten per cent. of the crop on some millions of acres in India, to the Panama disease which completely exterminates the susceptible bananas and precludes replanting within any reasonable time. The success of the measures which have been adopted to control these diseases also shows every gradation from the complete control which is easy to obtain by disinfection against sorghum smut or by growing Cavendish bananas in Panama-diseased land, to mere alleviation which appears to be all one can hope for, but is yet sufficient, against rubber mildew or the root diseases of limes. A consideration of these measures—ruthless eradication, the complete replacement of susceptible varieties, hybridisation or selection to obtain resistant plants, budding or grafting on resistant stocks, modifications in agricultural practices like stubble burning or pre-watering, and finally, the direct attack on the parasite by steeping, spraying or dusting—indicates how varied is the task of the plant pathologist and how wide must be the foundations of his knowledge if he is to perform it successfully. The old conception of the mycologist, student of the fungi that cause disease, as adequately equipped to fulfil the duties of a plant pathologist, dies hard but it is dying. Like bacteriology in the realm of medicine, pure mycology is a necessary foundation and the mycologist a necessary collaborator but he is not equipped either as a general practitioner or a specialist in particular diseases."

"The practical man is often slow to admit that a destructive disease in a plant is due to agencies outside his control. Confronted with such he is inclined to seek for explanations other than the true one. He looks first for some disorder brought about

by cultivation or inbreeding, or meteorological phenomena. Or he thinks that the soil is unsuitable or has become exhausted, or that the plant, if an exotic, has failed to become acclimatised. It is often not until all these have been tested and found wanting, that the true cause is fully realised. Experience has shown that it is unfortunately rare to find the explanation of serious disease in these directions and the dominating factor is usually the presence of a parasite, however much its activities may be favoured by secondary causes."

"Failure to recognise the very varied weapons used by modern plant pathology and undue weight given to the secondary factors in the causation of disease have led, no doubt, to the suggestion that the 'mycologist,' as he is still called in most of the British Colonies, may be in danger of losing his position as one of the most essential members of any team of tropical research agriculturists. In actual fact there can be no question that, looked on as a member of a team and relying on the collaboration that must exist between him and the plant breeders and agriculturists, the plant pathologist is more needed now than ever."

OBITUARY.

Sir Daniel Morris, K.C.M.G.

It is with deep regret that we have learnt of the death in England, at the age of 89, of Sir Daniel Morris.

Sir Daniel, who was born in Loughor, Glamorgan, on 26th May, 1844, was educated at the Royal College of Science and at Trinity College, Dublin, where he took first class honours in Natural Science. Sir Daniel's first civil appointment was as Assistant Director of the Royal Botanic Gardens, Ceylon. In 1879 he became Director of the Botanic Department, Jamaica, and in 1886, Assistant Director of the Royal Botanic Gardens, Kew. Whilst at Kew, he was sent in 1890 on a special mission to the West Indies and in 1896 he acted as Scientific Adviser to the West Indian Royal Commission. In 1898, Sir Daniel returned to the West Indies as Imperial Commissioner and was entrusted with the organisation of the work of the newly created Imperial Department of Agriculture. No better person could have been chosen for this post which he filled with distinction for eleven years. Perhaps of Sir Daniel's many achievements during those years, the most outstanding was his successful introduction into the West Indies of the cultivation of Sea Island cotton. When in 1908 he joined the Colonial Office as its Scientific Adviser in tropical agriculture, the reputation of the Imperial Department was not only very high in the West Indies but also throughout the Colonial Empire. It is, however, with the development of West Indian agriculture that Sir Daniel's name will chiefly be remembered for no man did more in his time to further its cause.

COCOA PLANTERS' ASSOCIATION.

Report for 1931-1932.

During the year ended 30th June, 1932, the membership of the Cocoa Planters' Association again showed an increase and now totals 268, compared with 254 in the previous year, 145 ten years ago, and 90 twenty years ago. The total amount of cacao handled, however, fell from 68,204 bags (165 lb. each) in the previous year to 45,138 bags, the crop being very poor throughout the island. The price created a new low record being $7.35 (£1 10s. 7½d.) per fanega (110lb.) compared with the previous lowest of $7.60 (£1 11s. 8d.) obtained in 1930-31. Members were charged 19 cents (9½d.) per fanega for working expenses but, as only 13 cents (6½d.) per fanega was actually expended, a sum of $3,994.03 (£832 1s. 9½d.) was added to the Deferred Deposit Fund bringing the total to $54,233.07 (£11,298 1s. 1½d.). Short crops, low prices, and heavy expenditure on the control of witchbroom disease, combined to make the season the most disastrous that has been experienced within living memory. Large numbers of cacao proprietors are now reduced to the most desperate financial straits.

There are two points of particular interest connected with the year's operations. The first is that 715 bags of superior cacao were sold at an average price of $10.25 (£2 2s. 8½d.) per fanega, or $2.90 (12s. 1d.) more than that realised for the standard 'mark'. This substantial premium was particularly welcome last year, and indicates both the possibility and profitableness of grading.

The second point is that the Pembroke Co-operative Fermentary for the fourth year in succession continued to expand its membership and quantity of cacao handled. Last year 27 members supplied 214 bags of cacao. During the year another Fermentary was established at Roxborough with a membership of 21 and a crop of 111 bags. This year each Fermentary expects to handle between 300 and 400 bags of cacao. So far the Fermentaries have maintained their quality at the Cocoa Planters' Association standard. Both have expanded so rapidly that they have been unable to provide adequate accommodation for the drying of cacao, and unless they are able to obtain the capital necessary for immediate and substantial additions to their drying space a large quantity of inferior quality must result.

At the present time the members are receiving the equivalent of a first payment of 5 cents (2½d.) per lb. for dry cacao, compared with 3½ cents (1¾d.) per lb. obtained by peasants who are forced to dispose of their cacao to the local village produce dealers. The success of the existing societies has led to a demand for additional Fermentaries in other districts in Tobago but so far these groups of peasants have been unable to raise the necessary capital.

C. Y. S.

MANURIAL EXPERIMENTS WITH SUGAR-CANE.

VI.—THE COMPLETE EFFECT OF AN INORGANIC MANURE AND VARYING DRESSINGS OF PEN MANURE ON THE YIELD OF PLANT, FIRST AND SECOND RATOON UBA CANES.

By P. E. Turner,
Soil Chemist to the Sugar-Cane Investigation Committee.

Although pen manure has been used as a manure for sugar-cane both in the British West Indies and elsewhere, for very many years, this appears to be the first occasion on which an experiment of this particular nature has been successfully carried through three crop stages to its logical end. It is now possible, therefore, from the standpoint of yield, to obtain a completed estimate of the value of pen manure, as a fertiliser, in comparison with an inorganic manure.

Part I.—Introduction and Details of Experiment.

(1) Introduction.

In the fourth paper of this series (2) details are given of a comparison between the effect of a complete inorganic manure, and single, double and triple doses of pen manure, on the yield of plant and first ratoon canes of the variety Uba. It is shown, *for the total yield of plant and first ratoon canes*, under the conditions of the experiment, that :—

(1) Each additional dose of pen manure results in a progressively smaller increment in yield.

(2) When pen manure is applied, the maximum financial gain is obtained from a dressing of 10 to 12 tons.

(3) The complete inorganic manure gives an increment in yield equal to that given by 30 tons of pen manure.

(4) The financial gain resulting from the use of the inorganic manure is far greater than the maximum gain to which pen manure can give rise.

Since the publication of these conclusions, the canes on the experimental area have been reaped for the third time, *i.e.*, as second ratoons. As no manurial treatment was applied to the second ratoon canes, yield and costings data are now available with regard to the total effect of the inorganic and organic manures on a complete crop series, *i.e.*, on plant, first and second ratoon canes.

Although pen manure has been used as a manure for sugar-cane, both in the British West Indies and elsewhere for very many years, this appears to be the first occasion on which an experiment of this nature has been successfully carried through three crop stages to its logical end. It is now possible, therefore, from the standpoint of yield, to obtain a completed estimate of the value of pen manure, as a fertiliser, in comparison with an inorganic manure.

(2) Details of the Experiment.

Soil Type.

A heavy, red-weathering clay, acid in reaction, deficient in humus and badly in need of flocculation.

Design of layout :—

Two 5 by 5 Latin Squares (*see* Table I).

Shape and Size of Plots :—

Twenty-two feet (the bed width) by 66 feet, = $\frac{1}{30}$ acre.

Data for the Plant Canes.

Manurial Treatments per acre :

(1) No treatment.
(2) Complete inorganic manure :
  (*a*) 90 lb. of Nitrogen as Sulphate of Ammonia.
  (*b*) 375 lb. of total P_2O_5 as Ground Rock Phosphate.
  (*c*) 60 lb. of K_2O as Sulphate of Potash.
(3) A unit dressing of 10 tons of Pen Manure.
(4) A double dressing of 20 tons of Pen Manure.
(5) A triple dressing of 30 tons of Pen Manure.

Yield of Plant Canes in tons per acre :—

Manurial Treatment.	Mean Yield.	Increment in Yield.
(1)	24.75	—
(2)	33.94	9.19
(3)	29.40	4.65
(4)	31.35	6.60
(5)	33.75	9.00

Data for First Ratoon Canes.

Manurial Treatments per acre :—

None.

Yield of First Ratoons in tons per acre :—

Manurial Treatment as Plant Canes.	Mean Yield.	Residual Increment in Yield.
(1)	15.64	—
(2)	21.075	5.43
(3)	18.30	2.66
(4)	20.70	5.06
(5)	21.49	5.85

Part II.—The Further Residual Effect of the Manurial Treatments on the Yield of the Second Ratoon Canes.

Manurial Treatment of Second Ratoons per acre :

None.

Age of Second Ratoons on Reaping :—11½ months.

(1) Yield Data for Second Ratoons.

The individual plot yields for the second ratoon canes are recorded in Table I. Weighings were made to the nearest quarter (28 lb.) The canes were burnt prior to reaping, as in normal estate practice.

Table I.

Plan of Experiment with Yield of Second Ratoon Canes in cwts. per plot.

J. A. POTTER.

(The treatment numbers are given in brackets).

Square I.

(1)	(5)	(4)	(3)	(2)
9.75	12.00	15.00	11.00	10.75
(4)	(2)	(1)	(5)	(3)
10.75	7.50	10.25	12.00	12.75
(2)	(1)	(3)	(4)	(5)
9.00	9.00	11.50	9.25	13.00
(3)	(4)	(5)	(2)	(1)
8.75	9.25	13.00	9.50	10.00
(5)	(3)	(2)	(1)	(4)
11.25	7.00	8.25	8.25	10.75

Square II.

(1)	(5)	(4)	(3)	(2)
8.00	9.00	11.00	11.25	13.25
(4)	(2)	(1)	(5)	(3)
9.50	8.00	8.50	11.00	9.25
(2)	(1)	(3)	(4)	(5)
8.25	6.50	10.75	12.75	12.50
(3)	(4)	(5)	(2)	(1)
11.00	12.00	12.25	10.75	9.00
(5)	(3)	(2)	(1)	(4)
8.00	8.00	11.25	8.50	8.00

Treatment Means.

(cwts. per plot).

Treatment ..	(1)	(2)	(3)	(4)	(5)
Mean Yield ..	8.775	9.650	10.125	10.825	11.400

(2) ANALYSIS OF YIELD DATA FOR SECOND RATOONS.

Use has been made of the analysis of variance (1) to allow for the variation due to squares, rows and columns. The analysis is set out in Table II.

Table II.

Analysis of Yield Data (Second Ratoon Canes).

ANALYSIS OF VARIANCE.

Due to	Degrees of Freedom.	Sum of Squares.	Mean Square.	$\frac{1}{2}\log_e$.
Squares ..	1	40.50	40.500	
Rows ..	8	552.48	69.060	
Columns ..	8	741.28	92.660	
Treatments ..	[4]	[665.48]	166.370	1.40582 (S)
(*a*) Quantity of pen manure ..	3	614.475	204.825	1.50978 (S)
(*b*) Inorganic manure *v.* mean effect of pen manure ..	1	51.005	51.005	0.81463 (N.S)
Error ..	28	778.04	27.787	0.51101
(*c*) *Interaction of Squares and Treatments ..	[4]	[221.40]	55.350	
(*d*) *Between parallel plots ..	[24]	[556.64]	23.193	
Total ..	49	2777.64	—	—

*(*c*) and (*d*) are both estimates of the same error. As their " mean squares " do not differ significantly, the " sum of squares " for each has been pooled in determining the estimate of error.

(3) General Statement of Results.

Table III.

Mean Yield of Second Ratoon Canes in tons per acre.

Manurial Treatment as Plant Canes.	Mean Yield.	Further Residual Increment in Yield.
(1) None	13.162	—
(2) Inorganic manure ..	14.475	1.313
(3) 10 tons pen manure ..	15.187	2.025
(4) 20 tons pen manure ..	16.237	3.075
(5) 30 tons pen manure ..	17.100	3.938

(4) Conclusions.

The significance of the further residual effect of treatment on the yield of second ratoon canes can be assessed from the data in Table II.

Pen Manure.

For P = 0.01, when $n_1 = 3$ and $n_2 = 28$, $z = 0.7595$. The difference due to pen manure in Table II is 1.5098 − 0.5110 or 0.9988. The further residual effect of pen manure might therefore be due to chance less than once in 100 times and is undoubtedly significant. *It may therefore be taken for granted that the influence of pen manure on yield extends to the second ratoon crop of canes.* The second residual increment in yield amounts, on the average, to 3.01 tons to the acre.

Inorganic Manure v. Average Effect of Pen Manure.

For P = 0.05, when $n_1 = 1$ and $n_2 = 28$, $z = 0.7171$. The difference in Table II is 0.8146 − 0.5110 or 0.3036. This is definitely not significant. *The yield of second ratoon canes* (14.475 *tons to the acre*) *on the plots which received the complete inorganic manure is not significantly different from the mean yield* (15.42 *tons of cane*) *on the remaining plots, which on the average received a dressing of* 15 *tons of pen manure to the acre.*

Part III.—The Effect of the Manurial Treatments on the Total Yield of Plant, First and Second Ratoon Canes.

(1) Total Yields of Plant, First and Second Ratoon Canes.

The total yields of plant, first and second ratoon canes, for the individual plots, are recorded in Table IV.

Table IV.

Yields in cwts. per plot.

J. A. Potter.

Latin Square I.

(1)	(5)	(4)	(3)	(2)
33.75	49.00	47.75	40.00	43.75
(4)	(2)	(1)	(5)	(3)
46.75	43.75	36.50	50.00	49.25
(2)	(1)	(3)	(4)	(5)
46.50	36.25	44.25	42.75	52.25
(3)	(4)	(5)	(2)	(1)
38.25	40.75	51.50	48.75	38.50
(5)	(3)	(2)	(1)	(4)
47.75	39.00	45.75	39.50	44.25

Latin Square II.

(1)	(5)	(4)	(3)	(2)
35.00	42.50	46.25	43.75	51.00
(4)	(2)	(1)	(5)	(3)
43.50	43.00	35.75	43.50	40.75
(2)	(1)	(3)	(4)	(5)
43.25	30.00	42.00	51.00	57.50
(3)	(4)	(5)	(2)	(1)
45.00	53.00	44.75	50.25	35.75
(5)	(3)	(2)	(1)	(4)
43.50	37.00	47.25	36.00	39.25

Treatment Means.

(cwt. per plot.)

Treatment ..	(1)	(2)	(3)	(4)	(5)
Mean Yield ..	35.700	46.325	41.925	45.525	48.225

(2) Analysis of Total Yield Data.

Table V.

Analysis of Variance for Total Yields of Plants, First and Second Ratoons.

Due to	Degrees of Freedom.	Sum of Squares.	Mean Square.	$\frac{1}{2}\log_e$.
Squares ..	1	81.92	81.92	
Rows ..	8	1858.80	232.35	
Columns ..	8	1775.20	221.90	
Treatments ..	[4]	[15635.12]	3908.78	1.8329 (S)
(*a*) Quantity of pen manure ..	3	14083.875	4694.62	1.9245 (S)
(*b*) Inorganic manure *v.* mean effect of pen manure ..	1	1551.245	1551.24	1.3708 (S)
Error ..	28	6465.68	230.92	0.4184
(*c*) *Interaction of Squares and Treatments ..	[4]	[966.48]		
(*d*) *Between parallel plots ..	[24]	[5499.20]		
Total ..	49	25816.72		

* The " mean squares " for (*c*) and (*d*) are not significantly different, and their " sums of squares " are pooled in the estimate of error.

Standard Error of a single plot $= \sqrt{230.92}$ qrs. Standard Error (mean of 10 plots) $= \sqrt{23.092}$ qrs. =4.81 qrs or 2.76 per cent. of the general mean (174.16 qrs).

Results of Analysis.

For P=0.01, when $n_1=3$ and $n_2=28$, z=0.7595. The difference due to quantity of pen manure in Table V is 1.9245—0.4184 or 1.5061. The effect of pen manure on total yield is undoubtedly significant, and might be due to chance far less than once in 100 times.

For P=0.05, when $n_1=1$ and $n_2=28$, z=0.7171. The comparison, inorganic manure *v.* average effect of pen manure, in Table V is 1.3708—0.4184 or 0.9524. *The effect on total yield of cane of the dressing of inorganic manure is therefore definitely significantly greater than the average effect of pen manure.*

The standard error of the difference between any two of the mean yields recorded in the first column of Table VI is equal to $\sqrt{2\times23.092}$ qrs. per plot or 2.5484 tons per acre. For P=0.05, t=2.048 when n=28. A difference, to be due to chance less than once in 20 times, must therefore exceed 2.5484×2.048, or 5.109 tons. Such differences are marked in Table VI with an asterisk.

For P=0.01, t=2.763 when n=28. A difference, to be due to chance less than once in 100 times, must therefore exceed 2.5484×2.763 or 7.041 tons. Such differences are denoted in heavy type in this table.

(3) General Statement of Results.

Table VI.

Total Yields of Plants, First and Second Ratoon Canes.

(tons per acre).

Manurial Treatment per acre.	Mean Yield	Difference from			
		Tr. (1)	Tr. (2)	Tr. (3)	Tr. (4)
(1) None ..	53.55	—	—	—	—
(2) Complete inorganic manure ..	69.49	**15.94***	—	—	—
(3) 10 tons pen manure ..	62.89	**9.34***	−6.60*	—	—
(4) 20 tons pen manure ..	68.29	**14.74***	−1.20	5.40*	—
(5) 30 tons pen manure ..	72.34	**18.79***	2.85	**9.45***	4.05

Mean yield due to treatment with inorganic manure .. .. .. =69.49 tons.
Mean yield on other plots (which received, on the average, 15 tons of pen manure) .. =64.27 tons.

Difference .. 5.22* tons.

(4) Conclusions.

The following conclusions may be drawn from the data in Table VI for the total yields of Uba plant, first and second ratoon canes on the red-weathering clay soil of the experimental area.

(1) *General.*

The pen manure treatments, irrespective of magnitude, and the complete inorganic manure, each give total increments in yield which might be due to chance far less than once in 100 times.

(2) *Single* v. *Double* v. *Triple Doses of Pen Manure.*

(*a*) The total yield of 68.29 tons of cane given by the double dressing is significantly greater than the total yield of 62.98 tons given by the single dressing.

(*b*) The total yield of 72.34 tons given by the triple dressing is not significantly different from that given by the double dressing.

(3) *Inorganic Manure v. Pen Manure.*

The total yield of 69.49 tons of cane on the plots which received the complete inorganic manure is:

(*a*) Significantly greater than that on the plots with a single dressing of pen manure.

(*b*) Significantly greater by 5.22 tons than the mean yield of 64.27 tons obtained from the remaining plots, which received, on the average, a dressing of 15 tons of pen manure.

(*c*) Not significantly different from the mean yields on the plots which received 20 and 30 tons of pen manure.

Part V.—The Fall-off in Yield during a Crop Series.

(1) The Fall-off of Increment in Yield.

The average increments in yield of plant, first and second ratoon canes on the plots which received pen manure and inorganic manure are given in Table VII. The data are recorded in graphical form in Figure I.

Table VII.

Increment in Yield in tons cane per acre.

Age of Cane.	Plants (1930).	First Ratoons (1931).	Second Ratoons (1932).
Inorganic Manure	9.19	5.43	1.31
Pen Manure (average for treatments (3) (4) and (5))	6.75	4.52	3.01

It will be seen from Figure I that there is a definite difference in slope in the curves for the fall-off of increment in yield corresponding to the two distinct types of treatment. Using Fisher's regression formulae (1) it may be shown that the increment in yield on the pen-manured plots appears to have gained on the increment on the plots which received inorganic manure at the rate of 2.07 ± 0.110 tons a year. Such an annual gain is significant. It might be due to chance less than once in 20 times.

The occurrence of a gain of this nature may be due to two causes. The fertilizer constituents of the pen manure may become more available with time. In addition there may possibly be a small but definite tilth effect of the pen manure.

The trends of the curves in Figure I suggest that the residual increment in yield due to the inorganic manure ceases with the second ratoon crop. The pen manure dressings, on the average, may increase the yield of third ratoons by an amount of the order of 1 ton to the acre.

(2) The Fall-off in Yield.

The average yields of plant canes and first and second ratoons for all plots are given in Table VIII. Each figure is a mean for 50 plots.

Table VIII.

Fall-off in Yield of the Crop Series.

Age of Cane ..	Plants.	First Ratoons	Second Ratoons
Mean Yield (tons per acre) ..	30.64	19.44	15.23

On the red-weathering clay soils, in this experiment, the yield of first ratoon canes is two-thirds that of the plant canes. The yield of second ratoons is one-half that of the plant canes.

Part VI.—Pen Manure as a Fertiliser.

The total quantities of nitrogen, phosphate and potash present in the complete inorganic manure and the various dressings of pen manure applied to the experimental area are recorded in Table IX.

Table IX.

Content of Nitrogen, Phosphate and Potash of the Manurial Treatments.

Constituent.	Pen Manure.			Inorganic Manure
	10 tons.	20 tons.	30 tons.	
Lb. N (total)	98.6	197.1	295.7	90
,, P_2O_5 (total)	44.8	89.6	134.4	375
,, K_2O (total)	141.1	282.2	423.4	60

It can be seen from the data in Table IX that *the dressing of 20 tons of pen manure, contains more than twice as much nitrogen, and more than five times as much potash, as the inorganic manure.*

It has previously been recorded that the amount of phosphate present in the inorganic manure could be considerably reduced, with advantage (2).

The Value of Nitrogen in Pen Manure.

A series of experiments carried out during the past five years have shown the red-weathering clay soils, on which this experiment was laid down, to be definitely deficient in nitrogen, and to respond to generous applications of this element when applied in the form of sulphate of ammonia.

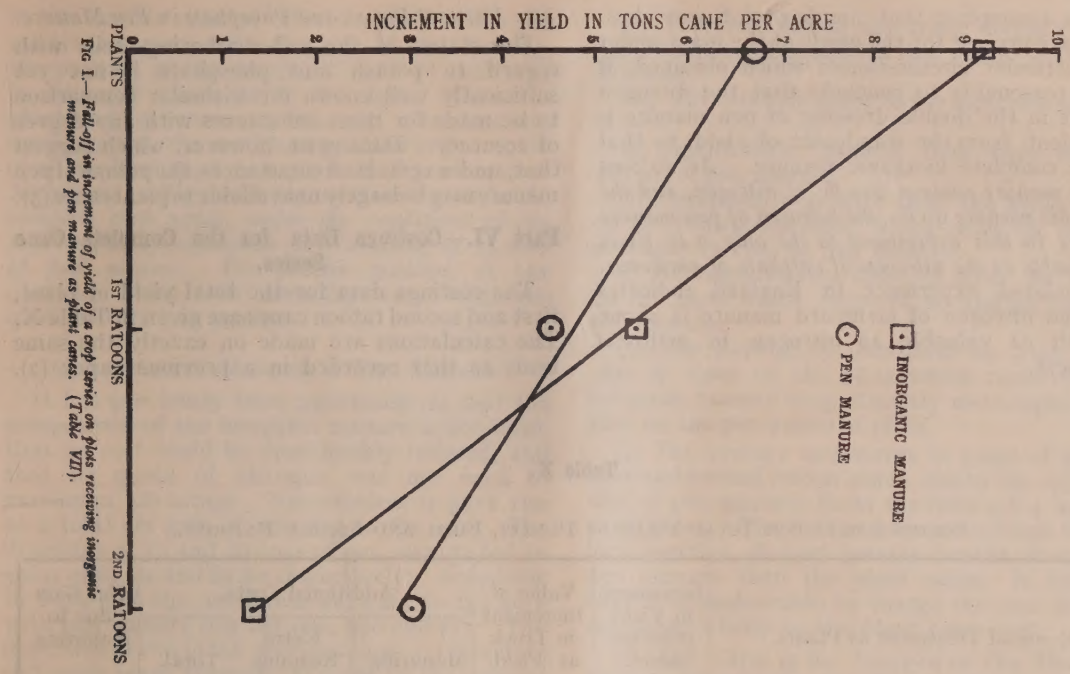

FIG I.—*Fall-off in increment of yield of a crop series on plots receiving inorganic manure and pen manure as plant canes. (Table VII).*

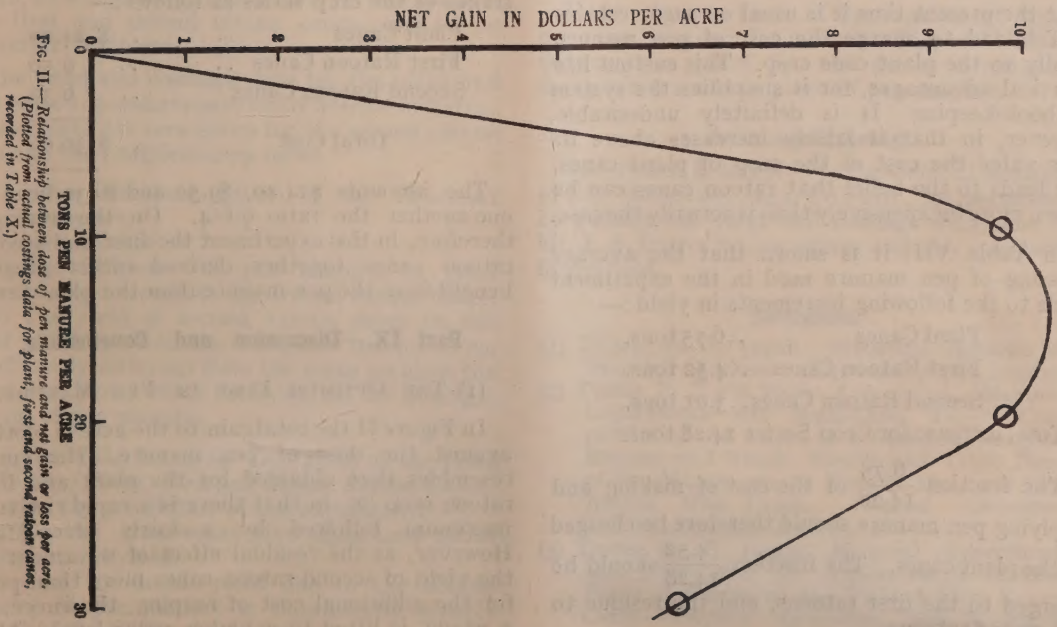

FIG. II.—*Relationship between dose of pen manure and net gain or loss per acre. (Plotted from actual costings data for plant, first and second ratoon canes, recorded in Table X.)*

On the assumption that ample potash and phosphate are present for the needs of the plant under the particular circumstances which obtained, it seems reasonable to conclude that the nitrogen present in the double dressing of pen manure is equivalent, from the standpoint of yield, to that of the complete inorganic manure. *As 20 tons of pen manure contain 200 lb. of nitrogen, and the inorganic manure 90 lb., the nitrogen of pen manure appears in this experiment to be only 0.45 times as valuable as the nitrogen of sulphate of ammonia.* Accumulated experience in England indicates that the nitrogen of farmyard manure is about one-half as valuable as nitrogen in artificial fertilisers.

The Value of Potash and Phosphate in Pen Manure.

The status of the red-weathering soils with regard to potash and phosphate is not yet sufficiently well known for a similar comparison to be made for these substances with any degree of accuracy. Data exist, however, which suggest that, under certain circumstances, the potash of pen manure may be largely unavailable to plant canes (3).

Part VI.—Costings Data for the Complete Cane Series.

The costings data for the total yield of plant, first and second ratoon canes are given in Table X. The calculations are made on exactly the same basis as that recorded in a previous paper (2).

Table X.

Costings data for Total Yield of Plants, First and Second Ratoons.

Manurial Treatment as Plants.	Increment in Yield (tons per acre).	Value of Increment in Truck at Field.	Additional Costs.			Net Gain due to manuring.
			Manuring.	Extra Reaping.	Total.	
	$	$	$	$	$	$
(1) None	—	—	—	—	—	—
(2) Complete inorganic	15.94	52.60	19.66	9.56	29.22	23.38
(3) 10 tons pen manure	9.34	30.82	15.50	5.60	21.10	9.72
(4) 20 tons pen manure	14.74	48.64	30.00	8.84	38.84	9.80
(5) 30 tons pen manure	18.79	62.01	44.50	11.27	55.77	6.24

Part VIII.—Apportionment of Cost of Pen Manure to Plant Canes, First Ratoons and Second Ratoons.

At the present time it is usual on sugar estates in Trinidad to charge the cost of pen manure wholly to the plant cane crop. This custom has practical advantages, for it simplifies the system of book-keeping. It is definitely undesirable, however, in that it falsely increases above its true value the cost of the crop of plant canes, and leads to the belief that ratoon canes can be grown more inexpensively than is actually the case.

In Table VII, it is shown that the average dressing of pen manure used in the experiment leads to the following increments in yield:—

Plant Canes ...6.75 tons.
First Ratoon Canes ..4.52 tons.
Second Ratoon Canes..3.01 tons.
Total increase for Crop Series 14.28 tons.

The fraction $\frac{6.75}{14.28}$ of the cost of making and applying pen manure should therefore be charged to the plant canes. The fraction $\frac{4.52}{14.28}$ should be charged to the first ratoons, and the residue to the second ratoons.

On the basis that pen manuring at the rate of 20 tons to the acre costs $30.00 (Table X), this expenditure should be apportioned to the three stages of the crop series as follows:—

Plant Canes ..	.. $ 14.20
First Ratoon Canes ..	.. 9.50
Second Ratoon Canes	.. 6.30
Total Cost	.. $ 30.00

The amounts $14.20, $9.50 and $6.30 bear to one another the ratio 9-6-4. On the average, therefore, in this experiment the first and second ratoon canes together derived rather greater benefit from the pen manure than the plant crop.

Part IX.—Discussion and Conclusions.

(1) The Optimum Dose of Pen Manure.

In Figure II the total gain to the acre is plotted against the dose of pen manure. The curve resembles that obtained for the plant and first ratoon crop (2), in that there is a rapid rise to a maximum followed by a fairly steep fall. However, as the residual effect of treatment on the yield of second ratoon canes more than pays for the additional cost of reaping, the curve, as a whole, is lifted to a higher value-level. Also,

as the further residual effect on yield of the pen manure increases with the size of the dressing, the position of the maximum point of the curve is displaced somewhat to the right. When the plant and first ratoon canes, only, are taken into consideration, the maximum gain lies in the region of an application of 10 to 12 tons of pen manure. According to Figure II, *the maximum gain for the complete crop series, under the conditions of the experiment, approximates to a dressing of 15 tons of pen manure.* The precise position of the optimum point will naturally vary with the quality of the pen manure.

(2) Inorganic Manure *v.* Pen Manure.

It has previously been mentioned (2) that the composition of the inorganic manure is not ideal, that its cost could be considerably reduced, and that its quota of nitrogen was not used to maximum advantage. Nevertheless it gave rise to a total net gain of over $23 to the acre. The dressings of 10 and 20 tons of pen manure led to gains of $9.72 and $9.80 respectively. According to Figure II the maximum net gain to the acre with pen manure lies between $10 and $11. The deduction drawn in the previous paper (2) therefore still holds when allowance is made for the residual effect of the pen manure treatments on the second ratoon canes. *Under the conditions of the experiment, sugar-cane can be grown far more cheaply, and without reduction in yield, by the use of a complete inorganic manure in place of pen manure.*

X.—Summary.

Details are given of an experiment laid down in 1928 to compare the effect on yield of sugar-cane of the following manurial treatments:—(i) None; (ii) Complete inorganic manure; (iii), (iv) and (v) 10, 20 and 30 tons, respectively, of pen manure. The first and second ratoon canes received no manurial treatment.

The yield and costings data for the plant and first ratoon canes have previously been recorded (2). Similar data are now given for the second ratoon crop and the complete crop series.

(1) *Further Residual Effect of the Manurial Treatments.*

It is shown that:—

(*a*) The influence of pen manure on yield undoubtedly extends to the second ratoon canes.

(*b*) The yield of second ratoon canes on the plots which received the inorganic manure is *not* significantly different from the mean yield on the remaining plots, which received, on the average, 15 tons of pen manure.

(2) *Effect of the Manurial Treatments on the Total Yield of Plant, First and Second Ratoon Canes.*

Under the conditions of the experiment:—

(i) All the treatments give significant increments in total yield.

(ii).—(*a*) The total yield due to the double dressing of pen manure is significantly greater than that due to the single dressing.

(*b*) The yield due to the triple dressing is not significantly different from that due to the double dressing.

(iii) The total yield due to the inorganic manure is:—

(*a*) Significantly greater than that due to 10 tons of pen manure.

(*b*) Significantly greater than the mean yield on the remaining plots, which received, on the average, 15 tons of pen manure.

(*c*) Not significantly different from the yields on the plots which received 20 and 30 tons of pen manure.

(3) *The Fall-off of Increment in Yield with Age of Cane* on the plots which received the inorganic manure is significantly more rapid than that on the pen-manured plots.

(4) The average increments in yield of plant, first and second ratoon canes, due to the application of pen manure, lie in the ratio 9-6-4 in this experiment. The first and second ratoons therefore together derived greater benefit from the pen manure than the plant canes. It follows that it is undesirable to charge the cost of pen manuring wholly to the plant cane crop.

(5) *The Value of the Nitrogen in Pen Manure.* In this experiment 100 lb. of nitrogen in the dressing of pen manure is equivalent to about 45 lb. of nitrogen in sulphate of ammonia, from the standpoint of yield.

(6) *The Optimum Dressing of Pen Manure,* for the complete crop series of plant, first and second ratoon canes, lies in the region of 15 tons to the acre. This dressing gives rise to a gain of from $10 to $11.

(7) *Pen Manure v. Inorganic Manure.*—The net gain due to the inorganic manure is over $23 to the acre for the complete crop series.

Under the conditions of the experiment sugar-cane can be grown far more cheaply, and without reduction in yield, by the use of a complete inorganic manure in place of pen manure.

Acknowledgments.

The author is indebted to the General Manager of Ste. Madeleine Sugar Co., Ltd., for permission to publish the yield and costings data, and to Mr. J. A. Potter for his willing and able assistance in the field.

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LOW PURITY MASSECUITES—II.

Crystallisation in Motion of Low Purity Strikes.

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IN a previous paper (1) the sucrose status of low purity massecuites during air cooling in an ordinary U-type crystalliser was discussed and certain suggestions for further investigations were made. During the past crop season, some of these suggestions were tried out at Bulkeley Factory where a U-type crystalliser had been provided with stationary coils through which hot or cold water could be circulated.

In the present investigation, the crystallisation of sucrose was followed in three low purity massecuites which were allowed to cool in the crystalliser under different conditions. The conditions were as follows :—

No. 1. Ordinary air cooling for 40 hours.

No. 2. Striking temperature maintained for 24 hours by circulating hot water through the coils ; followed by cold water circulation and rapid cooling for 24 hours.

No. 3. Striking temperature maintained for 10 hours followed by rapid cooling for 30 hours.

Four electrical resistance thermometers were installed at different places in the crystalliser and temperature readings were taken every hour. Samples of massecuite were taken from the crystalliser every two hours and an adequate sample of mother liquor was immediately separated from the massecuite. The samples of mother liquor were placed in air tight tins for subsequent analysis.

The compositions of the three massecuites are set out in Table I and it will be noted that there were no big differences in the analyses of the three strikes.

Table I.

Massecuite.	Dry Matter.	True Sucrose.	True Purity.
No. 1 ..	91.02	54.35	59.71
No. 2 ..	90.05	57.04	63.33
No. 3 ..	90.80	55.63	61.26

The samples of mother liquor were analysed for true sucrose and true dry matter and the coefficients of supersaturation were calculated from the formula :—

$$C_2 = \frac{S}{W.L_t.C_1}$$

where C_2 = coefficient of supersaturation.
S = sucrose.
W = water.
L_t = solubility of sucrose at t °C.
t °C. = temperature of massecuite at time sample was taken.
C_1 = saturation coefficient at the purity of the mother liquor.

In addition, the coefficients of supersaturation of the mother liquors were determined according to a modification of a method suggested by Harman (2). This is a very rapid and accurate method of determining coefficients of supersaturation and is described more fully as an appendix to this paper. It was found that there was very good agreement between the coefficients of supersaturation as determined by the two methods.

From the analyses of the massecuites and mother liquors, the percentages of crystal sugar in the massecuite at the different time periods were calculated according to the formula :

$$K = \frac{Q_t - Q_s}{100 - Q_s} \times 100\ J_t$$

where K = per cent. crystal sugar,
Q_t = true purity of massecuite,
Q_s = true purity of mother liquor,
J_t = true dry matter of massecuite.

The mean figures for each six hour period obtained for the three massecuites are set out in Tables I–III and the variations of temperature, in the per cent. sucrose crystallising out, and in the coefficients of supersaturation of the mother liquor with time are shown in Figs. I–III.

Table II.

MASSECUITE No. 1.

	Mother Liquor.			Massecuite.	
Time (hours).	Dry Matter.	True Purity.	Coefficient of Supersaturation.	Temp. °C.	Per cent. Crystal Sugar.
At discharge	86.70	45.67	1.256	66.7	23.52
2- 6	87.87	43.15	1.329	64.2	26.52
8-12	87.56	41.61	1.365	59.8	28.21
14-18	86.32	39.63	1.291	55.6	30.27
20-24	87.04	37.50	1.351	50.9	32.34
26-30	86.88	36.95	1.347	47.4	32.86
32-36	86.58	36.47	1.307	47.0	33.30
38-40	86.62	36.00	1.320	45.8	33.71
Total increase in per cent. crystal sugar					10.19

Table III.

MASSECUITE No. 2.

	MOTHER LIQUOR.			MASSECUITE.	
Time (hours.)	Dry Matter.	True Purity.	Coefficient of Supersaturation.	Temp. °C.	Per cent. Crystal Sugar.
At discharge	86.00	51.42	1.257	68.3	22.08
2- 6	86.14	49.13	1.235	68.5	25.13
8-12	86.23	46.72	1.204	68.2	28.07
14-18	86.15	46.40	1.197	68.4	28.44
20-24	85.81	47.62	1.191	68.5	—
26-30	86.06	45.95	1.272	61.2	28.95
32-36	85.81	45.72	1.331	54.1	29.21
38-42	86.02	43.58	1.373	48.9	31.52
44-48	86.32	42.65	1.485	39.5	32.47
Total increase in per cent. crystal sugar					10.39

Table IV.

MASSECUITE No. 3.

	MOTHER LIQUOR.			MASSECUITE.	
Time (hours).	Dry Matter.	True Purity.	Coefficient of Supersaturation.	Temp. °C.	Per cent. Crystal Sugar.
At discharge	86.60	47.31	1.225	68.9	24.04
2- 6	87.03	44.01	1.229	68.5	27.97
8-12	87.21	43.13	1.263	66.3	28.95
14-18	86.91	43.05	1.326	59.2	29.03
20-24	86.54	41.33	1.363	51.1	30.84
26-30	86.92	39.25	1.393	45.7	32.90
32-36	86.54	37.57	1.394	40.7	34.45
38-40	86.61	37.10	1.412	39.2	34.88
Total increase in per cent. crystal sugar					10.84

Discussion.

Massecuite No. 1.

A study of Fig. 1 shows that this massecuite cooled fairly rapidly in the first twenty-four hours, after which time the temperature of the massecuite had dropped to about 49° C., but, subsequent to this, the rate of cooling decreased considerably. The coefficient of supersaturation of the mother liquor increased for the first twelve hours from 1.26 to 1.36, indicating that the velocity of crystallisation had not kept pace with the lowering of the solubility of sucrose in the mother liquor as the temperature decreased. The velocity of crystallisation remained uniformly high at a coefficient of supersaturation of 1.35 until the temperature fell below 50° C. The speed of crystallisation then decreased very much, indicating that a higher supersaturation than 1.34 is necessary in the mother liquor in order to maintain the same velocity of crystallisation when the temperature falls below 50° C.

When the particulars of this massecuite are compared with those determined, in a previous investigation at Carrington Factory, for massecuites of similar purity and air cooled in U-shaped crystallisers, some slight differences are noted. The massecuites at Carrington Factory cooled less quickly than this one at Bulkeley Factory with the result that the velocity of crystallisation was able to keep pace with the decreased solubility of the sucrose in the mother liquor as the temperature fell. The coefficient of supersaturation of the mother liquor of the massecuite followed at Carrington Factory remained between 1.22 and 1.25 throughout the period of cooling and, as would be expected, the velocity of crystallisation was lower than at Bulkeley Factory where the coefficient of supersaturation of the mother liquor remained at about 1.35. At Carrington Factory it was found that the speed of crystallisation decreased fairly considerably when the temperature fell below 60° C. For the purpose of comparison particulars of this massecuite are shown in Fig. IV. From a study of Fig. IV, it is evident that under the slower conditions of cooling and lower supersaturation of the mother liquor, the velocity of crystallisation taking place in the Carrington massecuite is less than in the Bulkeley massecuite. The data recorded for the massecuite studied at Bulkeley Factory confirms the observation already reported that there is a relatively high supersaturation of sucrose in the mother liquor at the time of curing.

Massecuite No. 2.

As already mentioned, the striking temperature of this massecuite was maintained for a period of twenty-four hours by the circulation of hot water through the coils in the crystalliser. It was noted that this massecuite began to show signs of froth fermentation after it had been in the crystalliser for ten hours and frothing continued until the temperature of the massecuite was lowered by the circulation of cold water through the coils. The results of this experiment are of interest in that they indicate that the crystallisation of

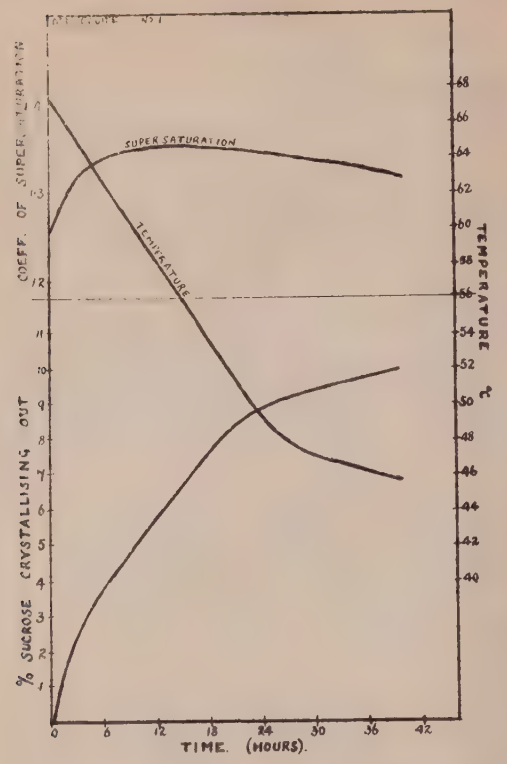

FIG I

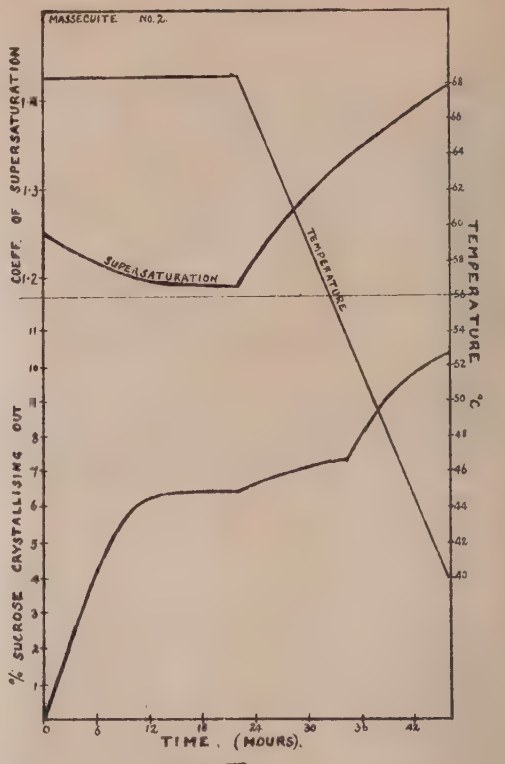

FIG II

sucrose takes place very slowly in these low purity massecuites at a temperature of 68° C., if the coefficient of supersaturation falls below 1.20. Crystallisation took place fairly readily for the first ten hours until the coefficient of supersaturation of the mother liquor had dropped to 1.20 and, then, for the next fourteen hours crystallisation ceased for all practical purposes. The crystallisation of sucrose which occurred during the first ten hours, appeared to be due not only to a drop in the coefficient of supersaturation of the mother liquor, but also to a further concentration of the massecuite.

On cooling the massecuite, the velocity of crystallisation remained relatively slow until at a temperature of 54° C. the coefficient of supersaturation of the mother liquor had risen to about 1.35. At this temperature and this supersaturation, the higher velocity of crystallisation was resumed. The cooling was carried out rapidly by the circulation of water and, as the increase in supersaturation shows, the sucrose crystallising out could not keep pace with the drop in solubility. It is interesting to note, however, that at a supersaturation of 1.4 and a temperature of 40° C. the velocity of crystallisation had decreased only slightly.

Massecuite No. 3.

It was intended to maintain this massecuite at its striking temperature for twelve hours and then to cool it rapidly by circulating cold water through the coils. Actually, cooling was commenced after ten hours since, after keeping the massecuite at 68° C. for this time, the massecuite showed signs of froth fermentation. As with Massecuite No. 2, sucrose continued to crystallise whilst the striking temperature was maintained; this crystallisation appears to have been mainly due to evaporation of water from the massecuite.

As with Massecuite No. 2, cooling did not increase the speed of crystallisation of the sucrose until the coefficient of supersaturation of the mother liquor had risen to over 1.3 at a temperature of about 60° C. Crystallisation then continued at an almost uniform velocity whilst the temperature fell from 60° C. to 40° C. in about 18 hours. During this time the coefficient of supersaturation of the mother liquor increased from 1.32 up to 1.4. This confirms the data obtained with Massecuite No. 2 where it was shown that even at a temperature of 40° C. the velocity of crystallisation will remain relatively high if the coefficient of supersaturation of the mother liquor is maintained at 1.4.

A consideration of the results obtained shows that the controlling factors influencing the velocity of crystallisation in these low purity massecuites are the temperature and the coefficient of supersaturation of the mother liquor. It was found that the speed of crystallisation becomes very slow when the coefficient of supersaturation drops to 1.2 at a temperature of 68° C. At a

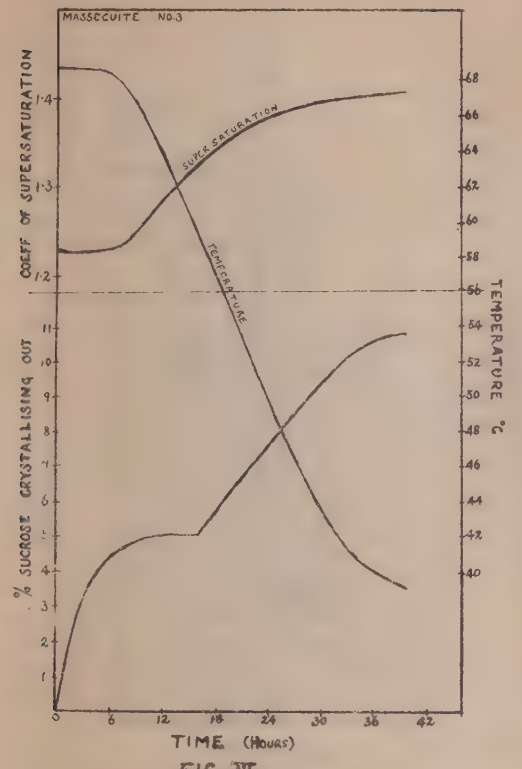

FIG III

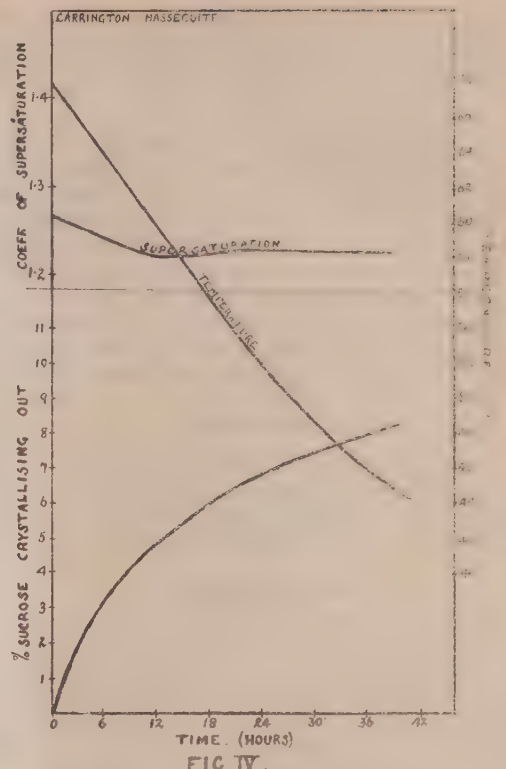

FIG IV.

temperature of about 70° C., a coefficient of supersaturation of 1.25 appears to be necessary in order to ensure an adequate velocity of crystallisation. As the temperature decreases and the viscosity of the mother liquor increases, a higher supersaturation is necessary, if the velocity of crystallisation is to be maintained. In Table V are set out the temperatures of the mother liquor with the minimum supersaturations at which similar velocities of crystallisation take place under the conditions which obtained in these experiments. If the coefficient of supersaturation drops below these values at these temperatures, the speed of crystallisation appears to decrease considerably.

Table V.

Temperature.	Coefficient of Supersaturation.
70°C.	1.25
60°C.	1.30
50°C.	1.35
40°C.	1.40

It will be noted from Tables II-IV that there is little difference in the total amount of sucrose crystallising out under the different methods of cooling which were adopted for the three massecuites. It can therefore be concluded that there is no great advantage to be gained by maintaining the striking temperature of the massecuite in the crystalliser since, although crystallisation of sucrose takes place for a time, the coefficient of supersaturation of the mother liquor is so reduced that considerable cooling has to take place before the coefficient of supersaturation can be raised sufficiently for a normal velocity of crystallisation to proceed at the reduced temperature. It is unfortunate that sufficient time was not available during the past crop season to investigate the effect of immediate rapid cooling of a massecuite on the coefficient of supersaturation of the mother liquor and the sucrose crystallising from solution. It is possible, of course, that the supersaturation of the mother liquor would have been raised to such an extent as to cause false grain formation. It is hoped to carry out further investigations on these lines at some time in the future.

Another important point which was brought out in the previous investigation is amply confirmed in these experiments. At the time of curing, a relatively high supersaturation of sucrose exists in the mother liquor and it is evident, that, under the time conditions prevailing in the average factory and from the relationship deduced between supersaturation, temperature and the velocity of crystallisation, it will be impossible to recover all of this sucrose. It is of interest to note that the supersaturations of the mother liquors of the three massecuites at the time of curing were such that the temperature of the massecuite could be raised to over 70° C. in each case without any sign of dissolution of the crystals in the massecuite. A

recognition of this fact would enable the temperature of the massecuite to be raised very considerably before curing and would result in the saving of much time at the centrifugals.

The apparatus described in the appendix will enable the temperature at which the mother liquor is just saturated and beyond which crystals will dissolve, to be determined rapidly. This temperature will indicate the limit to which the temperature of the massecuite should be raised before curing. Harman describes this as the saturation temperature and as he points out, a knowledge of this temperature is of the greatest value in the control of the crystallisation process.

Summary.

A study has been made of the sucrose status of three low purity massecuites under different conditions of cooling in the crystallisers and the results of this investigation are discussed.

Acknowledgments.

The author wishes to express his thanks to the owner of Bulkeley Factory for permission to carry out these experiments. He also wishes to express his appreciation of the ready assistance afforded him by Mr. F. Carrington, the Manager of Bulkeley Factory, and his staff, and to thank Mr. L. A. Hall who carried out much of the analytical work.

Appendix.

Harman (2) has shown how the saturation temperature of pure or impure sucrose solutions may be used to determine the coefficient of supersaturation and the saturation coefficient. This is an important paper since it describes a new principle upon which rapid methods for determining the supersaturations of sucrose solutions may be based. The method which Harman describes for determining the saturation temperature was not found very suitable for use with the low purity mother liquors described in the foregoing paper. Another experimental technique was accordingly evolved which, as it may prove of value to other workers, is here described.

The apparatus which is shown in Fig. V consists of a test tube, fitted with a thermometer and stirring rod, immersed in a water bath. The bath consists of a tall pyrex beaker in which the water is heated by means of a nichrome resistance wire made into the form of a cage around four uprights of glass rod. This wire is connected to a 110 volt supply of alternating current and the temperature of the wire is varied by means of an adjustable rheostat. By a suitable variation of the external resistance, the temperature of the water bath can be raised at any desired speed or it may be kept constant. Undue loss of heat from the water bath by radiation was prevented by placing it in a nest of cotton wool inside a larger beaker.

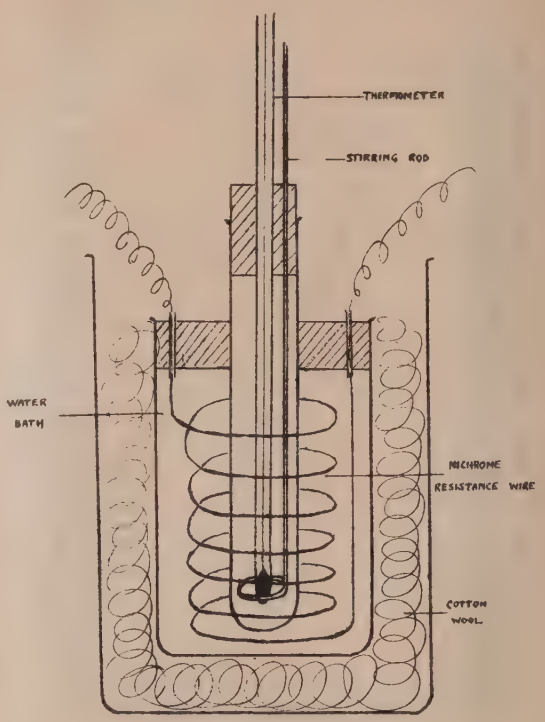

FIG. V

In the investigation reported upon, it was desired to determine the coefficient of supersaturation of mother liquors which had been separated some time previously and had cooled in air tight tins. These molasses were full of very fine grain and the saturation temperature was therefore the temperature at which all of these crystals just re-dissolved.

The sample of molasses of which the saturation temperature was to be determined, was placed in the test tube and the temperature of the water bath gradually raised. The molasses was kept stirred and the bulb of the thermometer which remained under the molasses was used to spot out samples of molasses on a cover glass as well as to record the temperature of the molasses. The smear of molasses on the cover glass was examined under a microscope and the temperature at which all the crystals had just disappeared represented the saturation temperature. As Harman shows, the solubility of sucrose at this temperature divided by the solubility of sucrose at the temperature at which the molasses was separated from the massecuite in the crystalliser, represents the coefficient of supersaturation of the mother liquor at the time it was separated.

For example, the saturation temperature of one sample of mother liquor was 85 °C. and the temperature of the massecuite at which this sample of mother liquor was separated was 68.9 °C. The coefficient of supersaturation of this mother liquor was therefore :—

$$\frac{\text{Solubility of Sucrose at 85 °C.}}{\text{Solubility of Sucrose at 68.9 °C.}} = \frac{386.9}{316.4} = 1.223$$

With the aid of this apparatus in the factory laboratory, the coefficient of supersaturation of the mother liquor could be determined directly on the massecuite. The samples of massecuite would be taken, placed as rapidly as possible in the test tube and the temperature raised as before. The saturation temperature of the molasses would be the temperature at which the sucrose crystals in the massecuite just commenced to lose their sharp edges.

Experiments were carried out to discover how quickly the sucrose crystals responded when the mother liquor was made unsaturated. It was found that there was little or no time lag and that after the first half minute no further dissolution of the crystals took place even if the temperature was kept constant for as long as ten minutes. The method adopted was to raise the temperature of the molasses rapidly to 70°C. or higher, if the known supersaturation of the molasses permitted, and then, when 3-5°C. from the saturation temperature, to raise the temperature of the molasses ½°C. at intervals of one minute. A sample was taken for inspection under the microscope after the temperature of the molasses had been maintained for half a minute. This was continued until the saturation temperature was reached. Duplicate determinations showed that the saturation temperature could be obtained with precision to the nearest ½°C.

It was found to be of advantage to have a thermometer immersed in the water bath and to maintain the temperature of the water a few degrees higher than the desired temperature of the molasses. When the temperature of the water bath was adequately controlled by means of the rheostat, there was no difficulty in obtaining an accurate control of the temperature of the molasses.

After these low purity molasses had been raised to their saturation temperatures and all the fine grain had disappeared, it was noticed that, on cooling, re-crystallisation took place very slowly. For instance, a molasses which was raised to the saturation temperature of 85°C. showed the first microscopic crystals after two hours and, at this time, the temperature had dropped to 40°C.

For fuller particulars of the use of the saturation temperature in the determination of supersaturations and saturation coefficients, reference should be made to Harman's paper.

References.

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POWER ALCOHOL.

THE commercial value of power alcohol has, according to the *Crown Colonist*, been tried and proved, and practically every country (including even the United States, the natural oil supplies of which might be thought to render it otherwise independent) has provided by legislation for its manufacture and use. In Germany and France especially, its use was instituted several years ago. It is only in the British Empire that the manufacture of power alcohol for commercial purposes has been comparatively neglected. The exceptions so far are Southern Rhodesia, where, after prolonged investigation, the Government gave its sanction to the new industry by granting it certain measures of protection; Queensland, where the industry was established with the financial assistance of the Government; and in England, where a single plant is in operation for the production of absolute (dehydrated) alcohol, to be converted into motor fuel.

Power alcohol is a spirit distilled from maize, molasses, sweet potatoes, and other crops. When mixed with plain petrol in varying proportions (the standard mixture favoured is 20 per cent. alcohol and 80 per cent. petrol) it gives a new motor fuel for which are claimed the following advantages over plain petrol: higher compressibility, quicker pick-up, and anti-knocking qualities. From the economic point of view, particularly, the advantages to be derived from its use lie in a market for surplus agricultural products on the one hand, and the cheaper cost to the fuel consumer on the other. For instance, it has been estimated that three distilleries in South Africa could produce annually 12 million gallons of alcohol, to produce with petrol, 80 million gallons of the new motor fuel to be sold at 1*s.* 6*d.* per gallon at the coast and 1*s.* 9*d.* inland. Having regard to the cost of importing petrol and its retail price in that Dominion, the great saving to the consumer there is at once obvious. Again, with maize on the "free list," the conversion of a great part of the surplus crop would prove a tremendous boon to the producer, with feed for his cattle as a valuable residue; and he could sell meat to England instead of maize.

Although a British scientist first discovered the process of obtaining alcohol from agricultural products, it has been left to foreign countries to develop the industry on commercial lines. In so far as the British Empire is concerned, the establishment of an "All-British motor fuel" is of considerable importance. So many millions of money go out of the Empire to foreign countries every year for the purchase of petrol that it is time to call a halt to what seems, in the circumstances, a needless extravagance. The rapid development of both road and air transport further emphasizes its importance. For example, there are no oil-wells along the Cairo to Cape air route. With power alcohol plants in the Sudan, East Africa and Rhodesia—all agricultural countries—this route could be kept open with greater independence of foreign petrol supplies. Southern Rhodesia at least has made a move in the right direction, and Kenya is giving serious consideration to the question.

The development of a product which would assist agriculture, and establish a new industry, is surely a matter calling for early action by the authorities concerned. Perhaps British East Africa will show the way.

STUDIES IN TROPICAL LAND TENURE.

By H. Martin Leake, sc.d.

VI.—Fiji.

The far distant islands, grouped under the name of Fiji, offer one of the most interesting cases of development which the British Empire has to offer. Ceded to Britain at a time when cannibalism was rife and human life of no account, it has, in the fifty odd years of British rule, evolved a contented people and a high standard of agricultural production. Lying far from the route of the early explorers, it lacked the glamour of the east. To these the Mecca was India and though Fiji was discovered by Tasman in 1643, it remained till late comparatively unknown and formed no bone of contention in international rivalry. The earlier settlers in the islands were content to establish their footing by treaty with the native chiefs and no status of Suzerainty was established by any European Power till the 10th of October, 1874, when a treaty of cession to Britain was signed by the various Chiefs. The causes which led up to that cession and the condition of the country at that period may be gathered from the account of Waterhouse (1). Section 4 of the deed of cession laid down that "the absolute proprietorship of all lands, not shown to be now alienated, so as to have become *bona fide* the property of Europeans or other Foreigners, or not now in actual use or occupation of some Chief or tribe, or not actually required for the probable future support and maintenance of some Chief or tribe, shall be and is hereby declared to be vested in Her Said Majesty, Her Heirs and Successors".

To Sir Hercules Robinson, then Governor of New South Wales, who was sent to discuss the terms of cession, fell the lot of forming a provisional Government. This early administration was, thus, faced with a dual problem; the determination of the validity of rights secured by settlers prior to 1874 and the determination of the limits of the areas owned by, and required for, the native population. If these two problems required an early settlement to establish a satisfactory basis for the future building of a land system, a third problem required to be solved to maintain the structure so established. Prior to the cession, land had been acquired by direct treaty with the Chiefs, the concession being usually registered at one of the Consulates. How unsatisfactory this arrangement was, the difficulties which arose in the settlement of these prior claims only too clearly showed. Freedom for the acquisition of further concessions of land by direct dealings with Chiefs must lead to renewed complication and in the provision of adequate means of securing land by non-natives on terms equitable to the native owner lay this further problem.

The three problems were attacked immediately and the general lines on which a settlement was to be based were laid down by Sir Hercules Robinson in his despatch of the 20th of December, 1874 (2). For the solution of the first problem he suggested the appointment of a Commission to enquire into the merits of each case and suggested that, where the transaction was upheld and adequate compensation was shown to have been paid, a Crown Grant should be issued. He expressed the opinion that the settlement would not be difficult if taken up immediately, but in that opinion he was hardly justified by events as is sufficiently indicated by the correspondence relative to the appeals against the decisions of the Commission and of the Executive Council which later reviewed the claims, under the Ordinance for the Final Settlement of Claims (Ord. 25 of 1819) (3). Sales by Chiefs, at best, left much to be desired in the matter of boundary definition and many claims were found to overlap. At the worst they were clearly extracted by playing upon ignorance, as when the concession involved all land lying between two parallel lines produced till they met! In all, the claims numbered some 648 and involved a total estimated area of 854,000 acres of which only 16,500 had been brought under cultivation. Complications arose, however, through the claims of non-British nationals and the question was finally solved by the British Government in upholding the local decision. The grounds of appeal were based on the argument that the Executive Council, being an interested party, could not sit in judgment, but it is of greater interest to note that, in the course of the discussion, the question was raised as to whether any of the claims were valid for the reason that, under native custom, no Chief had powers of alienation. That discussion led to an early study of native custom, a comprehensive note on which is recorded by the Rev. Lorimer Fison (4). For the settlement of the second problem the appointment of a Commission was also suggested by Sir Hercules Robinson with the suggestion that an expression of willingness to part with land indicates an excess above requirement. No immediate action was, however, taken for the problem was bound up with the question of customary native tenure and time was required for the investigation of this aspect. In 1876 the Native Affairs Ordinance (Ord. 7 of 1876) was passed establishing a Native Regulation Board to advise the Governor on such matters as he refered to it and the Board passed resolutions which received the approval of the Legislative Council. Concurrently investigation was made of local custom and in 1880 was passed the first Native Lands Ordinance (Ord. 21 of 1880). Under this Ordinance the Governor was empowered to appoint one or more Commissioners with the duty of ascertaining what lands were the rightful and hereditary property of native owners and it established a Register of Native

Lands which was to be kept by the Registrar of Titles appointed under the Real Property Ordinance (Ord. 6 of 1876). Survey must necessarily accompany such definition for, under the Ordinance, boundaries were to be marked on the ground, and provision for this had already been made by the Surveyors' Ordinance (Ord. 1 of 1877). The main provisions of this Ordinance were carried forward into the Native Lands Ordinance (Ord. 1 of 1905) which remains in force.

The third question was early determined by the decision of the Secretary of State that, in future, all transactions in land between natives and Europeans be forbidden and that, where such a transfer appeared desirable, the Crown should purchase and hand over the land in question (5). Section 3 of the Native Lands Ordinance of 1880 enacts this principle and the restriction is carried forward into the Ordinance of 1905. Transactions in land between natives and non-natives were, thus, limited to leases and, under the Ordinance of 1880 leasing was permitted with the consent of the Governor, the lease to be for a maximum of 21 years and to be registered with the Registrar of Titles.

With the settlement of these three questions the main lines of the land policy were early defined and further legislation is directed mainly to greater definition. Land ownership is trifold; Crown, native and non-native, and, under the Real Property Ordinance, is held in fee simple. Further legislation is concerned with facilitating equitable transfer from one to the other and, in this matter, the primary consideration is the provision and maintenance of adequate land for the native. Associated with this is the question of the nature of native custom as applied to land. It is a question that was also investigated with commendable promptitude. Reference has already been made to the report on native custom generally by Fison but more directly bearing on the land question is the report by Wilkinson on 'lala' or Fijian Service Tenure (6).

In his despatch already referred to, Sir Hercules Robinson had suggested that the Chief of every Quali should be recognized as acknowledged owner of the lands of the Quali or tribe and the guardian of the interests of his people while the people should be viewed as tenants with hereditary rights. The essential principle which was evolved from the discussions which followed, is incorporated in the Ordinances both of 1880 and 1905; it is that lands shall be held by native Fijians according to their native customs as evidenced by use and tradition and, subject to the provisions of the Ordinance, may be allotted and dealt with by native Fijians as among themselves according to their native customs. The basis of this tenure was one of "lala" the underlying principle of which was that the owner pays his wages in land and the tenant his rent in labour. "Lala", by custom, was limited to building, planting gardens, road-making, feeding strangers, cutting and building canoes, fishing turtle and any other works of public good (7). Governmental interference was limited to determining the person who should be recognized as owner and the duty of making this determination was allotted to the Commissioners under the Ordinance of 1880 and later, under the Ordinance of 1905, a permanent Native Lands Commission was appointed for the purpose. Lands were held communally by tribes bound by a common ancestral descent but subdivision was permitted and it was the Commission's duty to determine whether the land was held by mataquali or by whatever division or sub-division of the people.

In dealing with this question of native tenure reference may be made to the allied, and often associated, question of native taxation. Prior to the British occupation an ill-administered system of poll-tax was in force but appears to have been directed less to secure revenue than to secure power over the individual, and it became common for labour to be supplied to the plantations which paid the tax, receiving in return six months' service. With the establishment of British authority a provisional system of service commutable to a cash payment was introduced, but the system was shortly superceded by the system introduced by the Native Taxes Ordinance (Ord. 4 of 1876). This was a system of assessment by Provinces made by the Legislative Council with Provincial Boards of Assessors which distributed the amount by villages. The village assessment detailed the amount and description of produce which, when sold by public tender, would realize the amount assessed. The slight relation here apparent between taxation and productive capacity was later abolished and the Native Taxes Ordinance (Ord. 1 of 1913), which incorporates the Native Tax Commutation Ordinance (Ord. 2 of 1907) and is still in force, reduced the tax to a simple poll tax on all males between the ages of 16 and 60. The method of determination and assessment of the amount of the tax remained unaltered. Henceforth taxation is entirely divorced from land tenure and becomes associated with the regulations controlling the labour supply. It is unnecessary, therefore, to follow the later developments of the system of taxation of the native.

Flexibility in the matter of transfer of land between the three interests above noted is given and controlled by a number of Ordinances. As far as Crown Lands are concerned the Land Acquisition Ordinance (Ord. 1 of 1878) covers the acquisition of land by the Crown either by purchase or lease for public purposes. By the Crown Lands Ordinance (Ord. 1 of 1888), power to lease Crown Lands is conveyed and, under the terms of the lease, sub-letting is permitted; but the lease cannot be sold, transferred or in any way hypothecated without the consent of the Crown. The Crown has a further interest in land. Under the original settlement land was provided adequate to the needs of the tribe. But the tribe is a fluctuating body, in some cases increasing, in others diminishing in numbers; its land requirement is, therefore, a fluctuating quantity.

Under the Native Lands Ordinance of 1905 power is taken to adjust the quantity of land to the needs of the tribe. Under that Ordinance, if a mataquali cease to exist by extinction, the lands fall to the Crown as ultimate owner and is held for disposal as the Governor in Council may think fit, being either retained as Crown Land or distributed to other divisions of the people. If, falling short of extinction, the mataquali becomes so reduced in numbers that the lands cannot be fully cultivated, Government may purchase the land and distribute the remnant of the mataquali among other mataqualis. To meet the needs of expanding mataqualis wide powers are given by the Ordinance.

The transfer of rights in land as between native and non-native offers a more interesting problem. As has been indicated, direct purchase was early prohibited and all such purchases became indirect through Government. By 1912 sales of native land for which Crown Grants had been issued amounted to 20,184 acres making, with the recognized claims dating from before the British occupation, 414,615 acres alienated. In 1912 such sales, except to Government, were prohibited (Ord. 3 of 1912) and land became available only on leasehold. Leases are dealt with under the Native Lands Ordinance of 1905 with its amendments and, as the memo of such leases indicates, land so leased is placed by the native owner at the disposal of Government to deal with, for and on his behalf, while the lease itself conforms to the terms of lease of Crown Land. Land is classified as agricultural or grazing land. The period of the former lease is of any length up to a maximum of 99 years and is subject to reassessment in the 30th and 60th years or the 33rd and 66th years according to the duration, any increase on reassessment being limited to five per cent. of the unimproved capital value of the land at the time of reappraisement. The period of the latter lease is 21 years renewable on reassessment for a further period of 21 years with the same incremental limit. If, during the course of the lease, land under a grazing lease is used for agricultural purposes, it is liable to reassessment. In the case of both leases conditions with regard to development are included. All leased land is subject to survey and the lease to registration. A certain security is conferred on the lessee by the Native Lands (Leases) Ordinance (Ord. 23 of 1912) under which, in the case of expiring leases, the Governor in Council is empowered to determine the amount of compensation for permanent and unexhausted improvements when the native owner refuses to extend the lease.

A further aspect of the land system, however, arises from the nature of the development which followed the British occupation. The plantation system, then common in Colonial development, created a demand for labour, and Fiji, like many other Colonies, turned to India for a supply. With the experience of these Colonies, particularly Mauritius and the West Indies, to guide them the Government established a controlled immigration system under which Indians were introduced between 1879 and 1916 when the system was abolished. Of the 62,837 introduced during that interval 24,665 were repatriated so that, many adopted Fiji as their permanent abode and, by the end of 1929, the total Indian population was estimated at over 75,000 or some 40 per cent. of the total population. As elsewhere, a large proportion of these immigrants turned to agriculture and a strong demand has arisen for small plots of land such as are characteristic of Indian settlement in all parts of the world in which they have settled. Large areas are now held on lease or sub-lease by Indians and special provision is made by the Ordinance of 1905 for the regulation of leases of under 10 acres extent.

In all these matters Government act merely as the agent for the native owner and order is maintained in what otherwise would become a scramble for land. It receives the rentals and hands over the sum after deducting 10 per cent. The actual distribution is defined by the Ordinance as follows:—

To General Revenue	10 per cent.
Per £ of the balance	
to the Roko of the Province	1s.
to the Buli of the Province	1s.
to the Turagai taukei (if any)	1s.
to the Chief of the Quali	2s.
to the Chief of the Mataquali	3s.
to the Mataquali	the balance

Those two other problems, Mining and Forestry, which have so often been the cause of administrative difficulty in other Colonies, have not assumed any serious aspect in Fiji. Prospecting has not laid bare any great mineral wealth while mining is almost unknown and such prospecting licences as are granted are issued under the Mining Ordinance (Ord. 3 of 1908) which places the whole subject under the control of a Board. Forestry is regulated by the Forestry Ordinance (Ord. 5 of 1913). Under it the Governor is empowered to declare by proclamation areas as reserved forests but, in the case of native owned land, the written consent of the owner is necessary. All contracts between natives and non-natives for dealing in forest produce require the consent of the Governor.

Fiji, thus, offers an example of an island in which a plantation and a small holding system have developed side by side and, to this extent, it resembles the West Indies. A further similarity, too, may be found in the existence of a settled Indian population but here the similarity ceases. The West Indies possess an indigenous population insufficient to affect the economic life while, in Fiji, the indigenous population forms nearly 50 per cent. of the total and owns the larger portion of the land. Much of the agricultural production is in the hands of small holders and on that production a considerable export trade is built up. There arises, therefore, that same problem, which is met with elsewhere, as to how the products so raised may be graded to the standards required by the world's markets and

how the crops so grown may be maintained in a healthy and vigorous condition. The first action coming under the term of plant protection was taken early to protect the promising coffee industry which was brought to an abrupt close by the introduction of the *Hemileia* disease, probably from Ceylon, the coffee industry of which was ruined by its severity. That action consisted of the passage of the Coffee-Leaf Disease Ordinance (Ord. 21 of 1879) but was not long lived, for the Ordinance was repealed in 1881. It was followed by the Animals Importation Ordinance (Ord. 4 of 1886), which is still in force with sundry amendments, and the Plant Diseases Ordinance (Ord. 18 of 1891) repealed and replaced by the later Ordinance of the same tenor (Ord. 3 of 1913). The latter Ordinance is permissive and empowers the Governor in Council to determine the species of plants and parts thereof the importation of which is prohibited, and to make regulations for any of the following purposes: inspection, prevention of the outbreak and dissemination of plant diseases, fumigation of clothing and personal effects, spraying or other treatment and destruction of condemned plants or parts of plants and to appoint inspectors for the purposes of the Ordinance. Under this Ordinance a large number of regulations have been framed from time to time notifying diseases, prescribing treatment and defining areas. By an amending Ordinance (Ord. 14 of 1926) regulations might also be framed for the purpose of making research into and combating the diseases and pests of the coconut tree and into the methods of improving the quality of copra. Both these Ordinances were repealed and replaced by the Noxious Weeds and Plant Diseases Ordinance (Ord. 21 of 1929).

Meanwhile another aspect of the agricultural problem was assuming importance. In the moister climates of the tropics especially, there is always a danger of certain plants, usually imported, taking control and becoming a noxious weed. This has been the case with *Lantana* which, introduced as a garden shrub, has spread as a pest successively over Ceylon and the sub-montane tract of the central Himalayas. Fiji has not escaped the danger and among its noxious weeds is that known locally as the Noogoora Burr, *Xanthium strumarium*, and responsible for the passing of the Noogoora Burr Ordinance (Ord. 2 of 1919). Under the Ordinance, importation and growth of the plant is prohibited and authority to prescribe steps for its eradication was taken. But the Ordinance is not confined to the Noogoora Burr; Section 18 authorizes the Governor in Council on resolution of the Legislative Council to extend the provisions of the Ordinance to any plant, shrub or tree and extension has been made to include *Clidemia hirta*, a tropical American plant, and the Water Hyacinth, *Eichhornia crossipes*, which has been such a pest in Assam and Bengal, in 1923; *Acacia farnesiana* in 1925; cotton (with exceptions), elephant grass (*Pennisetum purpureum*) and *Solanum torvum* in 1926.

The Noxious Weeds and Plant Diseases Ordinance of 1929 is most comprehensive and not merely an Ordinance consolidating the above mentioned Ordinances. While covering all the provisions of these and carrying forward the regulations in force at the time of its enactment, it extends control in certain directions. In addition to research in connection with the coconut tree and the preparation of copra, like provision is made for the control of banana production. Of a more general nature is the establishment of a system of licences for all nurseries &c. in which plants are raised for sale.

There has, thus, arisen a complex Governmental organization controlling many of the conditions under which the agriculture of the country is carried out and, in the case of the coconut and the banana, two products which supply an export market, directing an influence on the quality of the produce. This latter question has been approached from another aspect. Early recognition of the importance of securing a reputation for quality in an exported product led to the passing of the Fruit Export Ordinance (Ord. 6 of 1906). Under it the export of pineapples, bananas and citrus fruit is controlled by a system of licences, power is taken to specify the method of packing and the appointment of inspectors sanctioned with power to issue orders as to the method of handling the fruit. Under an amending Ordinance (Ord. 31 of 1927) power is taken to prescribe areas in which the purchase for export of bananas is prohibited except under licence.

With the same object of protecting the quality of exported copra the Copra Ordinance (Ord. 32 of 1927) was passed. The export of copra is, by this Ordinance, brought under a system of licences; it makes unlawful the purchasing of whole coconuts for making copra, making copra from nuts not naturally fallen, storing green and wet copra in bags, sacks or heaps, spreading copra in or on any drying place other than a kiln at a depth of more than four inches except for protection from weather, and mixing dry with wet or green copra and offering for sale copra mixed with sand or shell. It establishes a system of grading and inspection with two standard grades; 'F. 1st.', having not more than 4 per cent. free fatty acid, and 'F. 2nd.' with more than 4 but not more than 12 per cent. free fatty acid.

In all these Ordinances and Regulations no reference has been made to that major product of Fijian export, sugar, which, in 1930, constituted some 57 per cent. of the value of the Colony's total export even when molasses is excluded. The reason for this apparent omission lies in the history of the sugar industry. The suitability of the island for the cultivation of the sugar-cane was early appreciated and a number of small mills and plantations were established during the seventies of last century. Sugar has, however, been the sport of legislative action in all countries and, further, the period has been one in which those great strides were being made in the development of the manufacturing process

which have led to the central factory requiring large capital outlay. Against these forces the small producer was unable to struggle successfully and the history of the Fijian industry is one of absorption. In 1880 the Australian Sugar Refining Company (later the Colonial Sugar Refining Company) commenced operations in Fiji and it has gradually extended these operations until, by 1926, with the absorption of the Penang Company, the last independent producer of sugar, it now holds a monopoly of sugar production in the islands with a potential output of over 100,000 tons from its five factories.

But the main interest of this development lies in the agricultural aspect. The Company itself possesses, mainly on lease, a number of plantations and, from the first, it encouraged the production of cane by independent European plantations and leased out estates to former employees whom it financed. It was the demand for labour on these plantations which was responsible for the establishment of the indenture system and the large influx of Indians which followed. Largely on account of the cessation of indentured immigration in 1917 and the labour troubles which followed, this plantation system ceased to be profitable and the estates fell back on the Company. Concurrently, the Indian, following his instinct, as he passed from his indentures, sought land; and a demand arose for small holdings which the Company met by dividing up their plantations into blocks of approximately ten acres each of which they leased. Land was also available on native owned property under the Native Land Ordinance of 1905 as already described. There has, thus, arisen a large Indian peasantry growing among other crops, rice, cotton and maize but also sugar cane; and for this development, rather, the profitable direction of this development, the Colonial Sugar Refining Company is largely responsible. Of the 78,000 acres under cane some 63,000 acres are cultivated on the peasant system, some 55,000 of which are cultivated by Indians, while the Company is responsible for settling some 2,000 families on 21,000 acres. Only 15,000 acres are retained for direct cultivation and this consists mainly of alluvial flats which lend themselves to large scale methods of farming (8). At the present time some 80 per cent. of the crop is raised by peasant farmers, the majority of whom are Indians (9). The stimulus which has produced this revolution in practice has been the shortage of labour which followed the cessation of the indenture system; its successful development has been due to the initiative of the Company in utilizing that instinct for peasant cultivation which is so characteristic of the Indian. The methods by which the success has been achieved are no less instructive. In the earliest attempts, a share tenancy (copartnership) system was adopted, the labour of cultivating and reaping being shared by the estate and the grower. Practical difficulties arose, however, which proved that system to be unworkable, and later a simple cash lease was introduced. But the peasant was not left entirely to his own devices in the matter of cane growing. The Company maintains a system of feeder lines which include some 160 miles of portable track and the land is worked on a definite rotational system, one quarter being planted to cane annually giving a plant cane crop in 16 to 18 months followed by a ratoon crop 12 months later. But the essence of the success of the scheme lies in the strict control maintained by a highly organized supervisory staff in close contact with the peasantry. Under the direction of this staff advances, as required, are made, implements supplied at low rates on a hiring system, supplies of manures organized and service by the Company's thorough-bred bulls provided. Under its direction, too, cane is reaped under a system of grouping the peasants into co-operative gangs cutting each others' cane in rotation. These gangs are paid for their labour on reaping and laying lines and the charge debited to the respective growers. Payment is made at the weigh-bridge on a basis of 10*s.* per ton cane containing 13 per cent. obtainable sugar with a bonus of 1*s.* 3*d.* for every one per cent. sucrose in excess of 13 and a deduction of 1*s.* 8*d.* for every one per cent. sucrose below 13. Added to this is paid a bonus of 3*s.* 6*d.* per ton during the maintenance of the preferential tariff in Great Britain (10). Further assistance is given in many indirect ways which react on the welfare of the Company's tenants. Facilities for housing both as regards sites and materials for construction are provided and a spirit of emulation fostered by competition.

The results of this large scale experiment in peasant farming are to be judged by two standards. The Company is a commercial body and has to look to material results. On this narrower basis the success is undoubted and not the least reason for this is that the Company have wisely refrained from exercising their monopoly so as to secure cane at a reduced price and, further, it has fostered the idea of security of tenure. On that acid test of a cane farming system, yield, the system must be judged a success, for the yield from peasant cultivation in marked contrast to what is found elsewhere, attains the standard obtained by direct cultivation on the estates. It is a result which must be attributed to the influence of a trained supervisory staff having power to enforce a system of cultivation aimed directly at maintaining the fertility of the soil; and there is no doubt that, although the Company's tenants have to conform to restrictions as to cropping, these are in the best interests of the tenants and that the standard of cultivation is at a much higher level by this means than would otherwise be possible (11). A full account of the industry and its solution has been given by Dixon (12). On the wider basis of its effect on the standard of well-being and contentment of the peoples concerned, the system must also be judged a success, for it appeals to the peasantry as is indicated by the keen competition which exists for farms. Largely as the result of

this development it has been possible to say of the Indian in Fiji that the type in the second and third generations is physically and mentally superior to the ancestral (13).

This scheme of peasant cultivation on a tenancy basis, started as an experiment to meet the difficulties arising from shortage of labour, has now passed the experimental stage. An extension of the system is in progress which contemplates an area under direct cultivation only sufficient to train the supervisory staff and for experiment. A further extension to lands in native ownership and to native growers is also in progress but is likely to be a slower development for the reason that the Fijian is not so adept a cultivator as the Indian and, further, the enforcement of supervision offers a more difficult problem.

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COFFEE GRAFTING.

Preliminary Investigations in Grafting Coffee at Amani, East Africa.*

This paper describes various experiments which were carried out over a period of about eight months. Most of the experiments relate to grafts with *C. robusta* as the stock and *C. arabica* as the scion. At first, the main object in view was to discover whether grafting coffee could be successfully accomplished under the conditions prevailing at Amani. Results proved that successful grafting is fairly easy to accomplish and the suggestion is advanced that grafting could also be carried out successfully in other coffee-producing districts.

For grafting twelve to eighteen months old seedlings in the nursery beds, and stumps, or suckers in the field, the best type of scion is said to be obtained from the firm green wood of "chupons", between the mature brown wood to within nine to six inches of the tips. Each scion consists of a single node and four inches of the internode, the number of scions yielded by a "chupon" depending on the strength of the shoot and degree of ripeness of the wood. The best union was obtained by grafting on the stock at a point where the wood was firm and green and slightly older than the scion. In most of the experiments the ordinary veneer method of grafting was used.

When grafting was carried out during the rainy seasons it was not so successful as at drier periods and the theory is advanced that the ideal period for the operation is the cool, dry season, between the months of June and October.

Elaborate protection of the grafts is considered to be unnecessary and the method of using paper cylinders dipped in paraffin wax, which is reported to be successful in Java, is interesting from the point of view of cheapness. This method also eliminates the use of grafting wax.

A method of grafting *Coffea arabica* on to other species when both stock and scions are seedlings, at the cotyledon stage of growth, is described. No part of the stock was removed. A vertical cut was made through the plumule and the hypocotyl so that the cotyledons fell apart. The seedling forming the scion was severed just above ground level and the hypocotyl cut to form a long tapering wedge. The point of the wedge was inserted at the bottom of the slit in the stock so that all the cut surfaces were parallel. When the cotyledons of the stock were brought to their original position and the whole bound with a thin strand of raffia, the finished graft had the appearance of a seedling with two pairs of cotyledons, one above the other.

It is claimed for this method that (*a*) a very large percentage of successful grafts can be easily obtained. (*b*) no elaborate nursery apparatus would be required, and (*c*) that the operation would become a fairly speedy one after some practice by the operator.

Further data as to the subsequent behaviour of the plants in the field will, of course, be necessary, before this method of grafting can be justified.

Since this original paper was written the suggestion that the dry season is the best time for grafting receives considerable support from two recent publications.† The authors state that the surface feeding roots of the coffee plant are least active during the rainy seasons. In view of this data it is almost certain that the larger number of successful grafts obtained during the dry season was due, not to better conditions prevailing above ground for the actual union between stock and scion, so much as the greater activity of the feeding roots causing a maximum flow of sap in the stocks at that period.

K. E. T.

* *Kew Bulletin of Miscellaneous Information*, No. 9, 1932.

† (i) Coffee Cultivation with Special Reference to the Northern Province, Tanganyika, by F. R. Sanders and A. J. Wakefield. Pam. 7. *Department of Agriculture*, Tanganyika Territory.

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PRELIMINARY TRIALS WITH A COMBINED INSECTICIDE AND FUNGICIDE.

By H. R. Briton-Jones, D.Sc.

One of the most important weapons in the hands of entomologists and mycologists, in their endeavour to control insect pests and diseases caused by cryptogamic organisms, is the application of a spray fluid or dust which is known to be toxic to the particular pest or disease under treatment. Apart from the form in which the toxic material is applied to the surface of the plant, or to the soil in which the plant is growing, entomologists use two classes of insecticides generally known as contact insecticides and stomach poisons. The former kill within a short period of time after coming in contact with the pest, death in such a case being due to various causes including the blocking of the spiracles of the insect thereby making it impossible for the organism to breathe. The insecticide may also with, or without contact with the moist atmosphere, give off a vapour or produce a gas which is fatal to the insect. Similar fumigants are in use against some classes of fungi. In the case of stomach poisons, like the arsenical compounds which are so widely used, insects must feed on the portions of the plants which are covered by these and, not being able to do so without also absorbing the insecticide, they are thus poisoned. There is a definite draw-back to the use of these in tropical countries since they are quite often washed off by rain within a few hours of their application. Some fungicides also function as contact toxins but in the majority of cases their function is mainly in a protective capacity, that is, they protect, from subsequent infection by fungous spores or mycelium, the surfaces of the plant which they cover.

There are several insecticides and fungicides in use at the present time in most agricultural countries and some of them give excellent results when used for specific purposes. On the other hand, the vast majority of cultivated crops are attacked by various types of insects and fungi, and insecticides like Nicotine Sulphate and various arsenical compounds can, with advantage, be added to such standard fungicides as lime sulphur and Bordeaux Mixture respectively for use against a combined attack by insect and fungus. It is, however, generally accepted that such combinations are only applicable in a limited number of cases. In other words, plant pathologists all over the world, whether they be entomologists or mycologists, feel the need for a material which is procurable in a convenient form, easily prepared for application, cheap, effective as a contact insecticide and fungicide, and which will function as a protective against future infection. This, however, is an ambition which so far has not been realised.

Emulsions of oil and soft soap in water have been in use for many years and have well-served their purpose against scale insects and other pests. Furthermore, the use of emulsions known as "Tar Distillate Washes" as winter sprays in temperate climates is well known. Experience with the latter has shown that, unless appplied when the buds are still in a dormant condition, they cause considerable damage to the young leaves, bringing about defoliation. Knowledge of the latter fact led the writer to try the use of a few such winter washes against the American Leaf Disease (*Omphalia flavida*) on Arabian Coffee in Trinidad since complete defoliation was in this case highly desirable. These tests, however, failed on economic grounds since it was found that Arabian Coffee is tolerant of too high concentrations of such spray fluids. The problem of the control of the leaf disease of coffee was eventually solved by a special method of pruning. In the meantime, however, the writer was able, with the ready co-operation of the management and technical staff of a large Trinidad oil company to examine samples of several kinds of cheap bye-products. The materials first examined were complete failures for divers reasons but at a later date the investigation of further oil-compounds was considered desirable with a view to finding a means of killing the delicate growing points of cacao shoots as a factor in the control of Witches' Broom Disease. One of these products gave promising results and in addition to killing the growing points and causing defoliation it was also found to kill various types of insects, as well as lichens and mosses, which were present on the sprayed cacao trees. The effectiveness of the higher concentrations of the material against insects and epiphytic growths induced the writer to test it against insects at strengths which would not cause damage to the plants. These gave astonishingly good results and laboratory tests indicated that it was also effective against fungi.

As already stated, it is necessary for a fungicide, and in some cases for an insecticide, to function as a protective against further infection even if it kills what fungus there is already on the plant. The material under investigation did not appear to possess this property either as a fungicide or insecticide but the cheapness of the product in its original form left a margin which indicated the possibility of incorporating a substance possessing such qualities. Investigation along these lines showed that the product was, in addition to having the highly desirable properties of ready miscibility with water and good wetting power, a solvent of elemental sulphur. Furthermore, that on subsequent dilution with water and when exposed to the atmosphere the sulphur in true solution became, as the result of oxidation, converted into colloidal form which is known to be very efficacious as a fungicide. Again,

colloidal sulphur, whilst serving as a protective against subsequent fungous infection, adheres well to the sprayed surfaces of plants and does not leave a visible deposit. Thus a cheap material was secured which appeared to be effective as a contact insecticide and fungicide and moreover served as a protective fungicide. One thing more remained to be done, namely, to incorporate a material which would function as a protective insecticide or stomach poison. In view of the fact that the spray fluid is so effective as a contact insecticide against adult and nymphal insects in general, it was considered that it would be more economic from the agriculturist's point of view if a stomach poison were found which could be added by the user on the rare occasions when it would be necessary. Various stomach poisons were tried with the result that it was found possible to add to the sulphur-oil compound calcium arsenate with lime. The amounts necessary are 2 lb. of lime and ½ lb. of calcium arsenate to 50 gallons of the wash. The lime should be added and stirred before the calcium arsenate. The oil-sulphur compound as manufactured is known as "Sulphemulsol". As will be seen the chemical properties and the tests already carried out give strong evidence of the efficacy of this fluid against fungi and insects on several tropical crops which, in the main, are more tolerant of such fluids than plants grown in temperate climates. On the other hand, its non-injuriousness to dormant buds of plants which can be grown in both the tropics and temperate zones, together with its bark-cleaning properties, indicates that it may be of value as a winter wash in cold climates. Whether it can be used in dilute solutions on such plants in leaf is a matter for further investigation under the particular conditions under which such plants are grown.

"Sulphemulsol" as an Insecticide.

I. Stinging Ants (*Solenopsis gemminata*) on Grapefruit, Oranges and Mangoes.

Stinging ants make their nests in the soil at the base of the plant which they attack. They also protect themselves to some extent on the aerial portions of the host plants by making covered ways using soil for the purpose in the same manner as white ants. These stinging ants are most destructive in that they remove the bark, cortical tissues and cambium to such an extent that, if left unattended, they will kill bearing citrus trees over ten years old. In Trinidad, however, their most serious damage is caused to young citrus plants such as oranges, limes, or grapefruit which have been worked as scions on sour-orange stocks. It is interesting to note that this pest does not attack sour-orange stocks until after they have been budded. The extent of the damage caused in nurseries can be gauged from the fact that one planter expended about $80 in one year in combating this pest in his citrus nursery alone. All manner of ant syrups, &c., were tried but without success.

After some preliminary trials it was found that "Sulphemulsol" at four per cent. strength killed the ants within a few seconds and did not cause damage to the tenderest leaves and twigs of limes, oranges, or grapefruit. It was decided, therefore, to spray the whole nursery thoroughly with "Sulphemulsol" at four per cent. strength. The plants and soil at the crown were drenched with the spray with the result that the nursery was completely freed of this troublesome and destructive pest. The cost of the whole operation including labour and spraying material came to $3 90. At a later date after a period of wet weather the pest reinfected the nursery from outside. This point is both of interest and practical importance to citrus growers in Trinidad. Stinging ants do not cause much damage to citrus plants when the surrounding soil is firm and dry. On the other hand, sour-orange seedlings, which are raised as stocks for the above-mentioned citrus fruits, are in some localities very seriously attacked by Scab disease (*Sporotrichum citri*) and the best and most economic method of controlling this disease is to grow them under shade. This method of controlling Scab is now being adopted and it is no wild speculation to state that under shade conditions the moist soil will encourage stinging ants and they are likely therefore to become in future a more serious pest in nurseries than hitherto. On the other hand, the application of "Sulphemulsol" at four per cent. strength will prove a cheap and effective means of control. Likewise the shade in nurseries should be such as to be easily removed once the stocks have reached a condition of growth ready for budding.

II. Scale Insects on Grapefruit and Oranges. Purple Scale (*Lepidosaphes beckii*) and Florida Red Scale (*Chrysomphalus aonidum*).

These scale insects occur quite commonly on citrus trees in Trinidad but as a general rule they are much worse during the dry months than they are in the wet season. On the other hand if, for some reason or other, conditions of growth are unfavourable one or both these species can heavily infest citrus trees at any period of the year. It is true that if the unsatisfactory conditions are rectified the scale insects will disappear and the citrus trees will in time recover from the damage. On the other hand, a spraying with an effective contact insecticide rids the affected tree of its parasite within a short space of time and the trees recover much more quickly. Furthermore, in the case of a protracted dry season, such as is sometimes experienced in the British West Indies in common with some other citrus-growing countries, rainfall becomes the limiting

factor so that it is highly desirable to assist the trees to tide over the dry period by killing the scale insects which at such times cause very serious damage bringing about defoliation and a general dying back of the younger branches.

Of the two species of scale insects mentioned above the Purple Scale is by far the more difficult to kill because of the difficulty of wetting the most recently deposited eggs which are protected in front by the body of the insect itself, in the rear by the two rows of previously laid eggs, and from above by the shield which protects the insect itself, its eggs and newly hatched crawlers (nymphs). With a good wetting spray-fluid all eggs, nymphs and adults of the Florida Red Scale can be wetted in one thorough application. After several preliminary trials to determine the range of tolerance of the affected trees to "Sulphemulsol" it was determined that three per cent. strength was the best to use for killing the scale insects.

In very heavy infestations, particularly of the Purple Scale, the empty shields of the insects which have been killed or have died through unknown causes often adhere on to the surfaces of the shields under which are found live adults, nymphs and eggs. In such cases it is, in spite of the excellent wetting qualities of three per cent. "Sulphemulsol," impossible to hit and kill all the eggs. It is, therefore, recommended to give a second application of three per cent. "Sulphemulsol" about three weeks to a month after the first spraying. In this manner the crawlers (nymphs) which have hatched out in the meantime will be killed and the eggs left, if any, will, as the result of the hatching out of the nymphs, and the contraction of the tissues of the parent insect following death as the result of the first application of the spray, be less protected and will become vulnerable.

A commercial grove of young grapefruit trees which was infested by both the Purple and Florida Red Scale was sprayed with three per cent. "Sulphemulsol" at the beginning of December, 1932, a few days after they had been heavily manured with pen manure. It was intended to give a second application later but careful examination of the sprayed trees a fortnight after the first spraying showed that the first application was so successful as to make further treatment unnecessary. The control rows were also examined and live scale insects were found in numbers. The grove was examined again on the 4th January, 1933, and it was possible to indicate from a distance the position of the untreated rows on account of the yellowish-green colour of the leaves and the fact that they were making no fresh growth. The treated rows on the other hand were sending out strong new growth and their leaves were dark green in colour. The dead scale insects had in the meantime been washed off by rain leaving the bark clean and healthy.

The writer wishes to point out that he knows of other sprays, including oil-emulsions, which are as effective as "Sulphemulsol" against the above scale insects but there are several very important points in favour of "Sulphemulsol" which must appeal to the practical grower and are as follows:—(*a*) citrus trees (several varieties of limes, oranges, and grapefruit have been subjected to test) in fruit can be sprayed, without damage to the fruit and the spray leaves no visible deposit. It should be noted, however, that three per cent. will damage trees in blossom; (*b*) the fluid at three per cent. will control the fungous diseases which are amenable to treatment by spraying. There is no evidence as yet that spraying in the citrus grove will tend to keep down storage rots but experience in other directions suggests this as a possibility owing to the deposit on sprayed surfaces, though invisible, of sulphur in colloidal form; (*c*) at a strength of three per cent., "Sulphemulsol" kills several other noxious insects including stinging ants though four per cent. was found to give a better economic result. Where necessary, the strength can be increased to four or even five per cent. for several varieties of citrus in leaf, provided the leaves have not been seriously injured beforehand; (*d*) a thorough drenching with three per cent. will kill mosses and lichens though four or five per cent. give better results in cases where citrus varieties in leaf can withstand such concentrations; (*e*) "Sulphemulsol" compares very favourably in price, at 30 cents (1*s.* 3*d.* a gallon f.o.b. Trinidad in non-returnable drums).

III. Thrips on Cacao.

When growth conditions are unfavourable—indeed the remarks already made in this connection concerning scale insects on citrus in these islands are also applicable here—cacao leaves are seriously damaged and consequently defoliated. Similarly as with scale insects on citrus an uncontrollable drought is one of the chief predisposing factors. Spraying with two per cent. Bordeaux Mixture has been practised to some extent in Trinidad as a means of control and although this gives good results it is doubtful whether, at the cost of $9.40 per acre per application, it is an economic proposition. This aspect of the problem has not yet been investigated for "Sulphemulsol" but it has been established that at two per cent. it causes the almost instantaneous death of thrips without doing damage to the cacao leaves. There is, of course, much in favour of "Sulphemulsol" in regard to price and the ease of preparation and application.

IV. Weevils in seed grain (*Calandra* spp. and *Pachymerus quadrimaculatus*).

The seed of cereals and various species of leguminous crops which are being stored for sowing purposes are often infested with boring

weevils. An immersion of the infested seed for one minute in a two per cent solution of "Sulphemulsol" is fatal to the insects and does not influence the germination of the seed. It has not, in the absence of such diseases in Trinidad, been possible to test this treatment against fungous and bacterial diseases which are carried on the seed. The cheapness of such a treatment and the effectiveness of "Sulphemulsol" as a contact fungicide suggests, however, that it is well-worth testing against smuts, &c., of wheat, barley, oats, sorghum as well as the other seed-borne diseases of various crops.

Steeping in a two per cent. solution for one minute and drying has been tested for its effect on germination on several kinds of seed including *Gossypium* spp., *Crotalaria juncea, Setaria italica, Phaseolus aureus, Andropogon sorghum* (several varieties), *Phaseolus mungo, Oryza sativa, Phaseolus vulgaris, Vigna sinensis, Phaseolus acontifolius, Sesamum indicum, Pennisetum typhoideum* and *Linum usitatissimum*. In none of these cases did the treatment adversely affect germination of the treated seed as compared with untreated.

V. Caterpillar on cherry tree (*Phyllanthus distichus*).

The caterpillar was of the Geometrid looper type which so far has not been identified. The preliminary tests took a little time so that when the whole tree was sprayed with "Sulphemulsol" at two and a half per cent. strength several of the caterpillars were over an inch in length. As a caterpillar pest this was perhaps one of the most difficult that could be dealt with by a contact spray for the following two reasons (i) being a looper it can lift itself out of the film of fluid and stand in an almost erect position; (ii) the caterpillar can lose all bodily contact with the tree by suspending itself in mid-air on a silken thread. In spite of this, however, several hundreds were killed but it cannot be claimed that the spray gave satisfactory control. On the other hand, the tree should another time be sprayed when the caterpillars were but a few millimetres in length and the few that would then escape death by contact could be poisoned by means of the simple addition of 2 lb. of lime and ½ lb. of calcium arsenate to every 50 gallons of wash. Other types of caterpillars have been tested on a small scale in the laboratory and encouraging results have been obtained with strengths of two and three per cent. of "Sulphemulsol."

VI. Caterpillar (*Laphygma frugiperda*).

This is a pest which causes considerable damage to maize crops in Trinidad and on trial it was found that strengths between one and two per cent. of "Sulphemulsol" killed the caterpillars within a few seconds. On the other hand, on account of the fact that liquid is withheld by the sheathing bases of the maize leaves the emulsion caused considerable damage to the sprayed plants. The effectiveness of the emulsion against the caterpillar was so positive, cheap and easy that it was decided to attempt to eliminate the damage to the plant by means of dilution with water soon after the emulsion had killed the caterpillar. Trials with two per cent. "Sulphemulsol" with subsequent spraying with water has given most encouraging results and it is hoped shortly to try this treatment on a field scale. The cost of the double spraying with two per cent. "Sulphemulsol" and later with water will be more economic than spraying or dusting with arsenical compounds which are very uncertain in wet weather and even in dry weather are far from satisfactory against this particular pest.

VII. Mealy Bugs.

Several species of mealy bugs have been subjected to spraying on a small scale with "Sulphemulsol" and at two per cent. strength it kills in a few seconds all those that have been tested as well as the nursing ants which are frequently in attendance on such insects. Cacao can withstand spraying with two per cent. when in full leaf but it is, of course, not possible to predict the effect of this strength on the other crops, which are attacked by mealy bugs, without trial under the particular conditions under which such crops are grown in different parts of the world.

"Sulphemulsol" as a Fungicide.

It has not been possible as yet to test this spray against fungi to the extent that would be considered fully satisfactory. On the other hand, the following experiments indicate that it functions both as a contact and protective fungicide.

I. Cacao.

Cacao pods artificially infected with the Black Pod fungus (*Phytopthora palmivora*), and incubated in a water-saturated atmosphere until the fungus produced a copious growth of its fructifications on the surface of the pod, have been used to test the effect of "Sulphemulsol" as a contact fungicide. Such pods have been sprayed with, and others dipped in a two per cent. emulsion and allowed to dry. Other pods have been treated in a similar manner using water instead of "Sulphemulsol." On drying, transplants of the surface mycelium and fructifications of the fungus thus treated have then been made on to sterilised malt-extract agar and potato-wedges in tubes. The fungus after treatment with water grew quite readily on the above media whereas those treated with the two per cent. "Sulphemulsol" failed to make any growth. The results with "Sulphemulsol" compared favourably with those obtained with two per cent. Burgundy Mixture. The above tests have been repeated several times.

II. Sugar-Cane.

Throughout the Sugar-cane growing islands of the British West Indies sugar-cane cuttings are generally steeped in some form of disinfecting

fluid before planting. In some islands the cuttings are steeped in milk of lime of approximately six per cent. strength. In others they are dipped in a solution of five per cent. commercial formalin for a few seconds and then planted.

Experiments have been carried out to test the efficacy of "Sulphemulsol" as a protective fungicide and its influence on germination.

I. Three separate lots of several cuttings were immersed in water, five per cent. "Sulphemulsol" and five per cent. commercial formalin for ten minutes, then dried and placed in a water-saturated atmosphere in a number of desiccators. After about four days those cuttings which had been steeped in water showed at the cut ends the growth of various species of fungi. The lots of cuttings treated with five per cent. "Sulphemulsol" and five per cent. formalin remained free of fungous growth for ten days and at the end of a fortnight but a few showed the presence of fungus mycelium at the cut ends. Later, the majority showed the development of fungous growth at the cut ends. This was to be expected since, after a time, the tissue contracted and split at the cut ends, thereby exposing tissue which had not come in contact with the formalin or "Sulphemulsol." It is interesting to note that the cuttings steeped in the formalin for ten minutes failed to germinate whereas no such deleterious effect was observed in the case of five per cent. "Sulphemulsol." There was definite evidence in this experiment of the protective influence of five per cent. "Sulphemulsol" against fungous growth on sugar-cane cuttings. Variety of sugar-cane used was P.O.J. 2878.

II. In this experiment four separate lots of cuttings of P.O.J. 2878 were subjected to different treatments—(1) steeped in five per cent. "Sulphemulsol" for ten minutes; (2) steeped in two per cent. "Sulphemulsol" for 30 minutes; (3) dipped in five per cent. formalin; (4) untreated. The cuttings treated with the two strengths of "Sulphemulsol" and with the formalin were then laid out to dry. All cuttings were planted in the field at the same time. The germination was satisfactory throughout and there was no difference between the treated and untreated.

This experiment showed that sugar-cane cuttings can withstand soaking in "Sulphemulsol" of five per cent. strength for ten minutes and of two per cent. strength for thirty minutes without inhibition of germination. Owing to the absence of suitable material the effect of "Sulphemulsol" against a fungus disease has not yet been tested on a field scale. Petri dish and other laboratory tests have all given good results but as is well known all such tests are open to criticism. The only reliable test for a spray against a fungous disease is to spray a diseased plant under field conditions. It is hoped that such a test will shortly be possible and will be reported upon later.

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BOOKS RECEIVED.

We have to acknowledge receipt of the following books:—

Animal Diseases in South Africa by M. W. Henning. Vol. I. Bacterial and Protozoal Diseases. pp. 405, 43 illustrations and index.

Vol. II. Virus Deficiency Diseases and Plant Poisons. pp. 406-878. 84 illustrations and index. *Central News Agency*, Johannesburg, South Africa; or, from *Messrs. Gordon & Gotch*, 75, Farringdon Street, London. E.C.4. Price 50*s*.

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We have to acknowledge with thanks the following books which have been presented to the Library:—

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Animal Diseases in South Africa.

By M. W. Henning. Vol. I, Bacterial and Protozoal Diseases. Vol. II, Virus and Deficiency Diseases, Plant Poisons. *Central News Agency, Ltd.*, South Africa. Price £2 10s. per set of two Vols.

South Africa is essentially a stock farming country, and, in consequence, during the last 50 years, considerable research on animal diseases prevalent in that part of the globe has been carried out with a resultant accumulation of valuable information on the subject. Up to date, this knowledge has been disseminated through a somewhat scattered literature, and Dr. Henning's aim has been to summarise the present position. He has managed very successfully to present in a single treatise a clear and complete picture of the results achieved. As the title indicates the book deals with South African conditions and is primarily of importance to the South African farmer. Many of the diseases mentioned are of world wide significance, and consequently some of the chapters are of general interest to anyone working with livestock in tropical or subtropical localities.

The wording is essentially technical in character and intended for the veterinarian rather than the average farmer. Furthermore, detailed descriptions of the causative organisms and their culture are given, while the farmer is chiefly interested in prevention and cure. As a reference, therefore, it could only be recommended to the veterinarian and to the more scientific minded section of the farming community.

The publishers are to be congratulated on the manner in which the work has been presented in two very readable volumes of a handy size. Both volumes are well illustrated, which greatly enhances the text. Volume I is confined to bacterial and protozoal diseases, and the second volume to virus diseases and plant poisons. Part IV on poisonous plants is worthy of particular note, as the importance of such plants in natural pastures on the incidence of animal diseases in tropical countries is frequently not sufficiently stressed.

The book undoubtedly forms a very valuable contribution to the somewhat scanty literature on diseases of stock reared under colonial conditions.

D. D. P.

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To *Bibliographia Genetica* IX, 1932, Dr. S. C. Harland contributes an article on "The Genetics of Gossypium", which is a masterpiece of condensation. Few tropical or sub-tropical crops have received as much attention from geneticists and cytologists as cotton, and probably of few have as many varieties and related wild species been collected together expressly for genetic study. Yet in less than seventy octavo pages the present state of knowledge in this branch is critically reviewed, and the essentials are extracted from seventy-six papers listed in the bibliography.

A classification of Gossypium is given, comprising eleven species wild and cultivated, whilst seven more are listed as insufficiently known for the determination of taxonomic relationship. The reduction of cultivated cottons to three species in the New World or 26-chromosome section and two species in the Old World or 13-chromosome section is a simplification of earlier classifications which is to be welcomed, and which illustrates well the services that genetics can render to taxonomy.

The bulk of the work is naturally concerned with the cultivated cottons, and in particular with the numerous attempts at Mendelian analysis which have been made by cotton breeders during the past quarter of a century. Under each character which has been investigated the main findings are given, and the summary concludes with a list of the factors so far definitely established in Gossypium and a table of linkage data.

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E. E. C.

Der Einfluss der Handelsdünger auf das Pflanzenwachstum und auf verschiedene Eigenschaften kalkarmer Mineralböden. (The effect of artificial fertilizers on plant growth and on various properties of lime-deficient soils), by Dr. Ing. Ludwig Schmitt. *Verlagsgesellschaft für Ackerbau M.B.H.*, Berlin, S. W. 11. pp. 188, price R.M. 9.

This book may be regarded as a collection of papers embodying the results of pot-culture and long-term field experiments at the Darmstadt Agricultural Experiment Station on various kinds of artificial manures. As some of these experiments have been continued for 30 years the results are of the greatest interest to agriculturists, and the range of the work has been so wide as to include the principal types of artificial fertilizers. The five main chapters of the book deal with numerous experiments on the effects of potash, phosphate, nitrogen, lime, magnesium, and aluminium. To present the results of long-term experiments on these fertilizers is to give valuable information to agricultural science at a time when the greatest attention is being focussed on this subject. The author has shown that the early pot-culture experiments often gave misleading results, while many field experiments were carried out on single soil types and for one year only. The Darmstadt experiments indicate that it is not always necessary to apply lime to an acid soil, as kainit rich in magnesia and also calcium cyanamide are capable of causing large increases in yield, the increase with magnesia-rich kainit being greater than that obtained with potash plus lime. The book is well illustrated by diagrams and photographs, and can be regarded as a valuable contribution to agricultural knowledge in temperate climates. In the tropics it is useful as a work of reference.

D. W. D.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Scheme for the Production of Alcohol and Dry Ice in Cuba. *Henry Arnstein.*

Recently as a means of restricting sugar production and promoting the alcohol fuel industry in Cuba, the author has recommended the utilization of the juices from the final mills for fermentation to spirit, only the juices from the crusher and first mills being retained for making sugar. He assumes that out of a total of 88 per cent. of juice, 28 per cent. shall go to the distillery, and 60 per cent. be worked up in the sugar factory. Following are the main steps in his calculation of costs and profits, so far as the motor fuel part proposition is concerned.

Cane ground, is assumed to be 381,041 tons; and the 28 parts of juice correspond to 121,240 tons of cane or 14,364 tons of sugar; 100 lb. of sugar yield say 7.3 gallons (U.S.) of alcohol; or a long ton of sugar yields 163 gallons of absolute alcohol. Hence 14,364 tons of sugar yield 2,341,332 gallons of alcohol and 15,452,791 lb. of CO_2; or, with 300 working days yearly, 7,800 gallons alcohol from the juice, and 2,666 from the molasses, per day, and from this there would be a total of 66,000 lb. CO_2 for dry ice per day.

Cost of production of the alcohol per gallon is said to be 6.5 cents, assuming the cost of production of 100 lb. of sugar as juice to be 11 cents, and that this 100 lb. sugar yields 7.3 gallons of alcohol, making the raw material for one gallon to be 1.5 cents, and fuel, labour, depreciation, interest, &c., to be 5.0 cents. It requires 2.5 gallons molasses to manufacture one gallon high-proof alcohol, and molasses being worth three cents per gallon at the mill, the cost of the raw material to make one gallon alcohol becomes 3 by 2.5, to which is added five cents for overhead charges, making 12.5 cents. Therefore, we have 7,800 gallons alcohol from the juice at 6.5 cents, $507; and 2,600 gallons from the molasses at 12.5 cents, $325, a total of 10,400 gallons costing $832, or 8.00 cents per gallon.

Gasoline costs 25 cents per gallon in Cuba, being subject to a ten cents per gallon duty, so that if alcohol is subject to the same impost its cost will be increased to 18 cents. Dry ice can be sold at one cent per lb., and costs 0.187 cents per lb. to make. Figuring up the net daily profits on 10,000 gallons alcohol and 66,000 lb. of dry ice, it gives $1,897, which corresponds to a return of eight per cent. on seven million dollars.

Following this are given some particulars of the plant and methods used. A modern distillery must be equipped with closed-top, steel fermenting tanks, with temperature regulating devices, pure yeast culture apparatus, and continuous stills, all of which improve both quality and yield of alcohol. Generally the tropical distillery produces a mash containing 6 per cent. of alcohol, but this can be increased to nine per cent. by using pure yeasts acclimatized to growth in more concentrated solutions. An account of dry ice production with illustrations is given.—(*Inter. Sugar. Journ.*, Vol. XXXV, No. 409, January, 1933.)

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Potash Recovery from Molasses. *H. S. Harkness.*

At the start of the 1932 crop the Hawaiian Sugar Co., faced with the problem of the profitable disposal of its molasses, decided to try burning it so as to recover most of the potash in the ash. They built three furnaces side by side connected to a central flue, each being 5 feet long, 5 feet high, and 3 feet wide (inside dimensions), built of brick, lined with firebrick. In the top of each furnace, a drum, made of cast-iron pipe, 12 inches in diameter, and 3 feet long, with flanged ends, was provided.

Eight angle-iron ribs, $\frac{1}{4}$ inch by $2\frac{1}{2}$ inches by $2\frac{1}{2}$ inches were bolted to the outside of each drum, the drum shafts consisting of one inch hydraulic pipe with suitable fittings, so that cold water could be kept running through while in operation. Over the top of each drum, the furnace was arched, and an opening 3 inches wide was left the full width of the arch. Through this opening the molasses were fed by means of a 2-inch header pipe equipped with 4 inches by $\frac{3}{4}$ inch nipples, so that it flowed fairly evenly over the full length of the drum. All three units were driven by a $\frac{1}{2}$ H.P. motor through a reduction gear at about $\frac{1}{2}$ a rev. per min. All this material was made up in the workshops.

In operation, it was necessary to keep a good stream of water running through the shafts, because of the intense heat. When the furnace had reached a high heat, the molasses valve was opened and molasses kept running over the drum into the fire, when it burnt, but not completely. As soon as it was partly charred, it was raked out of the furnace door, and allowed to continue burning in the open air, being later removed to a cooling floor, where it was turned over now and again. When combustion was complete, the ash was spread out in a layer 5 to 6 inches deep, allowed to cool for 12 hours, and bagged for transportation to the fields.

In this way it was possible to burn from 18.20 tons of molasses per day, the operation of the three furnaces requiring three men on the furnaces, and two bagging. A recovery of 2.5 to 3.0 per cent. of ash on the molasses was obtained, and the ash contained 32.0 per cent. of K_2SO_4, 21.1 of KCl, and about 3.1 per cent. of carbonate and hydroxide, say in all about 35 per cent. of K_2O. It is not pretended that this method of working is anything much better than experimental, as it should be possible to design a revolving drum furnace, from which the partly burnt ash is continuously scraped, cooled and bagged.—(*Inter. Sugar. Journ.*, Vol. XXXV, No. 409, January, 1933.)

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Sodium Acetate recommended as Flame-Proofing Agent for Wood.

Since stone and steel exhibit certain disadvantages in construction, wood is again being more widely used as building material. Carl G. Schwalbe, Director of the Institute for Wood Research in the Forestry Hochschule at Ederswalde, and his co-worker, Kathe Berlin, recommended sodium acetate with or without the addition of disodium phosphate as a new cheap flame-proofing agent for wood. The most effective impregnation of wood with this salt is obtained by treating the green, or air-dried, lumber with the salt solution under pressure. This process is, in general, not applicable to structural wood. However, sufficient protection can be effected by dipping the timbers into a solution of the salt, or by applying to the wood in several coats a sufficient quantity of the salt solution to saturate the outer layers of the wood with salts of organic acids. Furthermore, spraying is recommended under certain conditions. A 15 per cent. (*anhydrous salt*) solution of sodium acetate is very satisfactory.

The depth of penetration depends, of course, upon the thickness of the treated boards, planks &c. The degree of dryness and the so-called storage age of the wood also play a part. The cost of this new treatment is much less than that obtainable with preparations used heretofore. The usual additions of other salts, though apparently unnecessary, can be made without increasing the cost of the preparation, and with such supplements protection against fungi and insects may be obtained simultaneously with fire protection. (*Indus. Eng. Chem.*, News Edit., Vol. X, No. 24, Dec. 20, 1932, p. 309.)

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A New Source of Rubber.

In order to avoid the necessity of importing rubber from tropical countries, the Soviet Government has organised investigations of native plants likely to contain this valuable product in their latex. Amongst various plants studied, several species of *Chondrilla* (Compositae) occurring mainly in the southern sandy regions, proved to be very promising and their cultivation is being carried out on an extensive scale. Green parts of the plant are cut and rubber prepared from the latex. The quantities obtained must be rather small, since only up to 2 per cent. of the green mass represents rubber. Recently, however, it was found that certain insects feeding on roots of *Chondrilla* can be utilised for extracting rubber from the latex (Veltischev and Luppova, *Priroda*, No. 10, 1932). One of these is a caterpillar of a pyralid moth, *Brodyrrhoa gilveolella* Tr., which feeds on the roots and constructs round its body a tube formed of condensed latex and sand grains. Up to thirty and more such tubes can be found on the roots of a single plant, and the tubes contain 9 to 17 per cent. of rubber. Another useful insect is the larva of a buprestid beetle, *Sphenoptera foveola* Gebl., which also feeds on roots of *Chondrilla* and causes a large outflow of latex solidifying round the root. These swellings contain up to four per cent. of rubber. Neither insect produces any serious effect on the infested plant, and healthy plants can be infested artificially in order to increase their productivity. Experiments are being made to test the practical and economic side of this method of obtaining rubber.—(*Nature*, Vol. LXXXI, No. 3297, 1933, p. 21.)

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Calcium Cyanamide for destroying Lawn and Pasture Weeds.

A note, published in *The Journal of the American Society of Agronomy* for January, 1933 by D. G. Sturkie of the Alabama Polytechnic Institute describes some remarkable results obtained by using Calcium Cyanamide (Nitrolim) on lawns of Bermuda Grass (Bahama Grass, Devils Grass, *Cynodon dactylon*), as well as lawns of Carpet Grass (Savannah Grass, *Axonopus compressus*), Dallis Grass (*Paspalum dilatatum*) and Centipede Grass (*Eremochloa ophuriodes*). In the Southern United States, areas colonised by these grasses are frequently infested with winter annual weeds which persist into spring. The commoner weeds are Chickweeds (*Stellaria media* and *Cerastium viscosum*), Crane's-bill (*Geranium carolinianum*), Cud-weed (*Gnaphalium purpureum*), Henbit (*Lamium amplexicaule*), Peppergrass (*Lepidium virginicum*), Plantain (*Plantago* sp.), Wood Sorrel (*Oxalis stricta*) and Crab Grass (*Digitaria sanguinalis*). (*Note.* Most of these grasses and weeds are listed in Grisebach's *Flora of the British West Indian Islands*, 1864). The experiments with Cyanamide were mainly confined to a lawn of Bermuda Grass, which was treated in February. Quantities varying from 200 to 2,000 lb. per acre were used, and the dressings were applied by broadcasting. It was found that all the weeds were killed by applications of 800 lb. and over. The grass grew well during the spring and summer, and showed marked stimulation due to the added nitrogen.

During May, other lawns were treated with Cyanamide to determine the effect of varying doses (500, 1,000, 1,500 and 2,000 lb. per acre) on the grass itself, and on surviving weeds, including Crab Grass. All the weeds and the Crab Grass were killed during the growing season by dressings of 1,000 lb. or over, and most of the weeds by a dressing of 500 lb. In all cases, the Bermuda Grass was killed, or its leaves were badly scorched, but, recovery generally followed after about two weeks.

Similar results were obtained with lawns of the other grasses. In all cases again, the foliage was severely scorched, but fresh growths soon appeared. The stimulating effect of the nitrogen contained in Cyanamide was evident in the subsequent crops. The treatment may be similarly efficacious when applied to pastures.

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Market have ranged as follows (c.i.f. per cwt.) :—

	Foreign.		*Preferential.*	
	s.	*d.*	*s.*	*d.*
29th Dec. ..	5	0	9	9
6th Jan. ..	5	0¾	9	9¾
12th Jan. ..	5	0	9	9
19th Jan. ..	4	9	9	7½
26th Jan. ..	4	10½	9	9
2nd Feb. ..	4	9¾	9	7½
9th Feb. ..	5	1½	9	10½
(11*th Feb.*, 1932) ..	6	5¼	10	1½

The continuance, according to *C. Czarnikow, Ltd.*, of the present unfavourable technical conditions in Raw Sugar markets has brought a decidedly easier tendency both in New York and in the United Kingdom. Although the present market situation is not altogether unexpected, in view of the existing restricted outlet for 'free' market sugars, there are indications from private reports of the probability of important reductions in plantings this year, especially in Java, which should lead to an improvement in the statistical position. In the meantime, under the influence of the general atmosphere of gloom surrounding every commodity market, the vitality of the sugar markets has been considerably undermined and there has been a tendency to ignore favourable features and to give almost exaggerated significance to adverse factors.

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COCOA.—The Cocoa market is still under the influence of depressed economic conditions and prices look like going to a new low level. At time of writing prices may be quoted as follows: Accra on the spot at 24*s.* 6*d.* to 25*s.* and to arrive at 23*s.* c.i.f., Plantation Trinidad 28*s.* to 32*s.* per 50 kilos cost and freight, Superior Summer Arriba 47*s.* per 50 kilos cost and freight and locally $5.25 per fanega is usually paid.—(*By courtesy of the Cocoa Planters' Association of Trinidad Ltd.*)

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COFFEE.—Latest averages for Kenya include parcels at 105*s.*, 116*s.*, and 120*s.* a cwt., and quality coffee has been quite unaffected by recent declines in Brazilian.

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COPRA.—Prices have declined and West Indian f.m.s. is now quoted at £14 2*s.* 6*d.* c.i.f. for February shipment.—(*West India Committee Circular*, 19th January.)

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association :—

	American Mid.	*Egyptian F.G.F. Sakel.*
30th Dec. ..	5.29	7.27
6th Jan... ..	5.33	7.56
13th Jan. ..	5.30	7.53
20th Jan. ..	5.25	7.35
27th Jan. ..	5.15	—
3rd Feb. ..	4.94	—
10th Feb. ..	5.09	
(12*th Feb.*, 1932) ..	5.59	7.45

Prices have generally shown an easier tendency and although trading continues small, very little buying would soon restore values.

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RUBBER.—Quotations for Plantation have ranged as follows :—

28th Dec.	2 7/16
4th Jan.	2 13/32
11th Jan.	2 7/16
18th Jan.	2 8/16
25th Jan.	2 7/32
1st Feb.	2 1/16
8th Feb.	2 3/32
(10*th Feb.*, 1932)	2¾

The rubber market has recently shown rather pronounced weakness, prices having fallen all round, largely on account of the liquidation of the article held by outsiders and the heavy offering of forward shipment for account of producers. The total consumption of rubber in America amounted in 1932 to 313,121 tons as against 348,986 in 1931 or a falling off of ten per cent.

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BANANAS.—A fair business has been done early in January, but the demand has been affected by cold and wet weather. Prices are unchanged at :—Jamaicas £21 5*s.* per ton delivered London and £21 nearest railway station ; and Brazilians £18 nearest station. The total imports into the United Kingdom for 1932 were 17,122,777 bunches against 16,161,900 bunches in 1931.—(*West India Committee Circular*, 19th January.)

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TEA.—Latest averages for tea (18th January) include Ceylon 8.91*d.*, Indian 7.21*d.*, and Java 5.89*d.* Prices since the beginning of the year have shown little change. Imports of tea for 1932 were very heavy, 518 million lb. as against 476 for 1931, the increase being in Empire tea exclusively.

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GRAPEFRUIT.—Average prices ruling in Covent Garden recently for popular sizes, 80's/126's were :

	s.	*d.*		*s.*	*d.*
Trinidad	22	6	to	25	0
Jamaica	12	0	to	15	0
Florida	18	0	to	22	6
Jaffa	14	0	to	16	0

—(*West India Committee Circular*, 19th January.)